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(54) **ENGINE OUTPUT ADJUSTMENT SYSTEM AND VEHICLE INCLUDING THE SAME**

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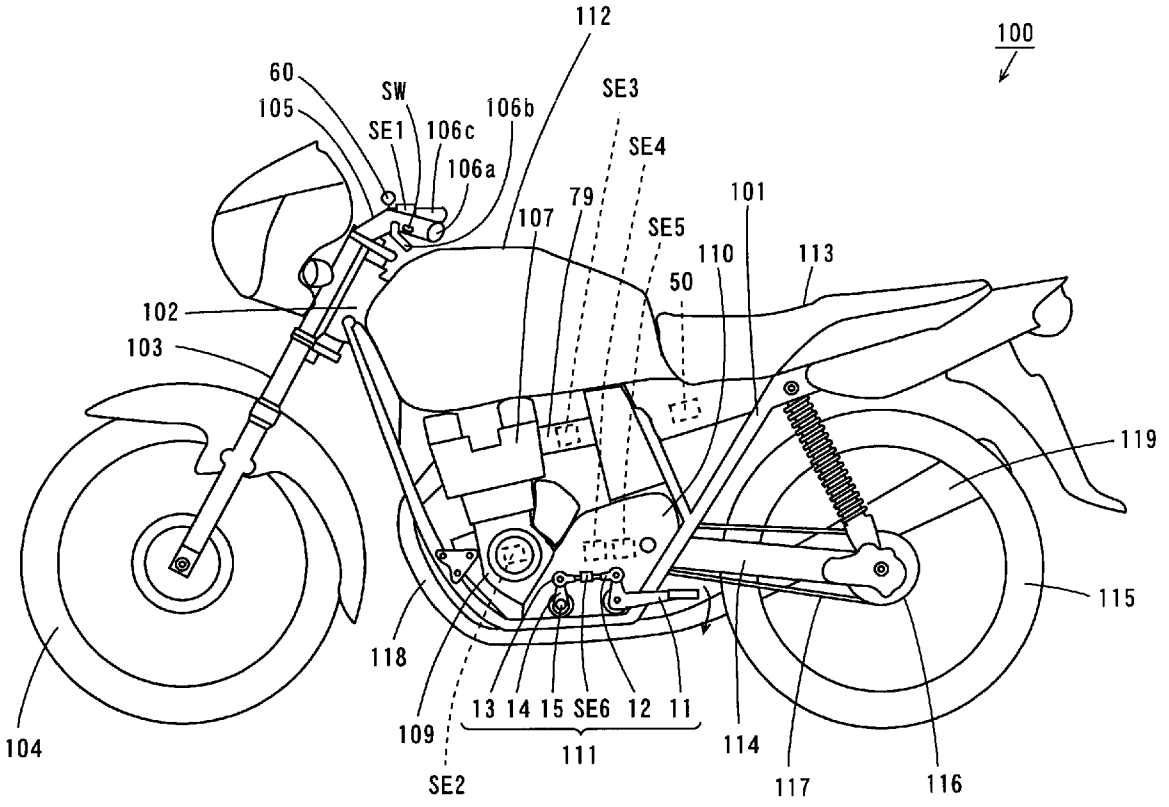
(57) **ABSTRACT**

A motorcycle includes an engine, a CPU, a clutch lever, and a shift switch. When a driver performs a shift operation, the CPU adjusts an output of the engine. When the CPU adjusts the output of the engine, the turning operation of the clutch lever is inhibited by the shift switch.



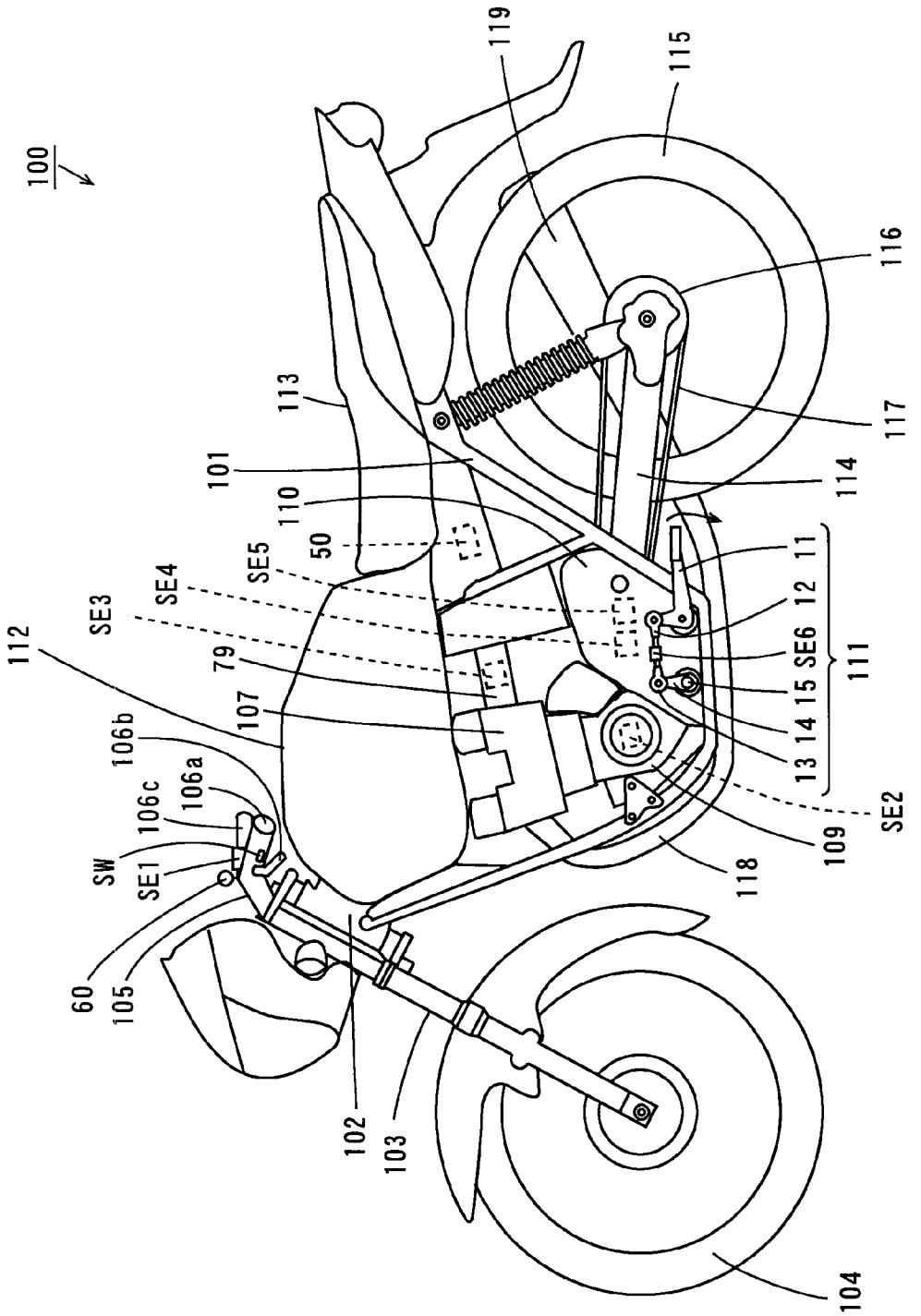

100
119
115
116
117
114
113
101
110
50
SE5
SE4
SE3
112
79
107
106b
106a
106c
SW
SE1
60
105
102
103
104
11
12
SE6
15
14
13
111
SE2
109
118

FIG. 1

FIG. 2

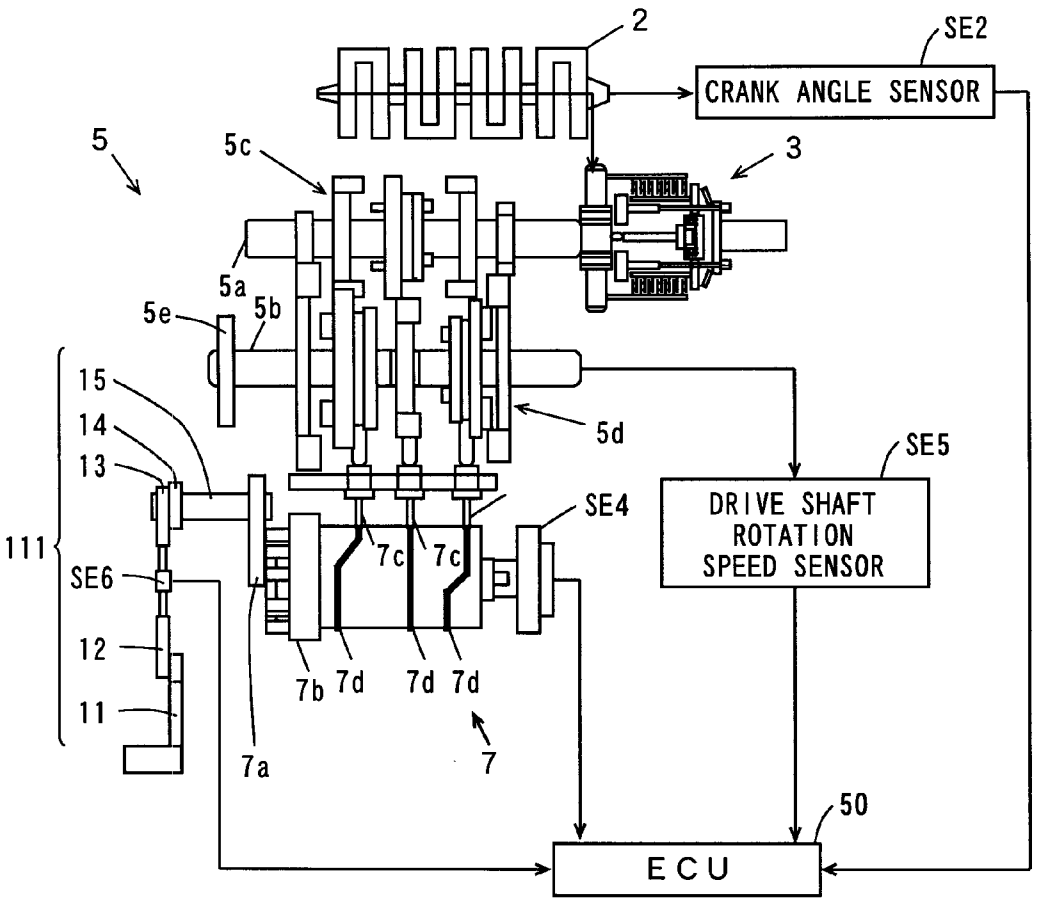

2
SE2
CRANK ANGLE SENSOR
5
5c
3
5a
5b
5e
15
14
13
111
SE6
12
11
5d
SE5
DRIVE SHAFT ROTATION SPEED SENSOR
SE4
7c
7c
7b
7d
7d
7d
7a
7
50
ECU

FIG. 3A

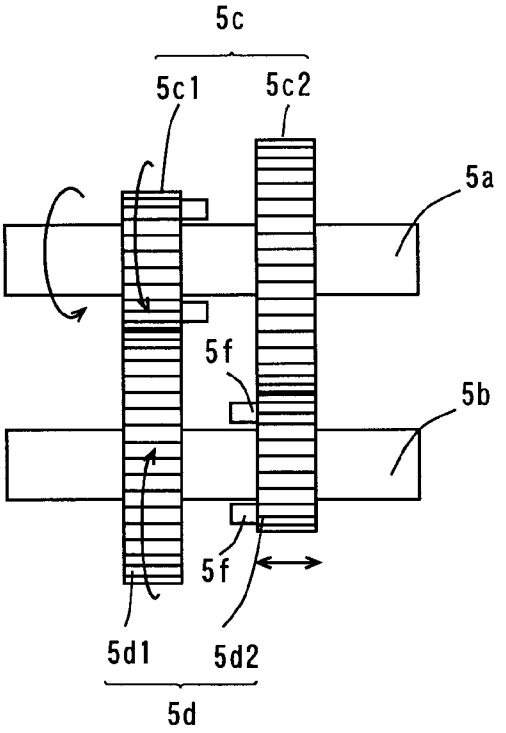
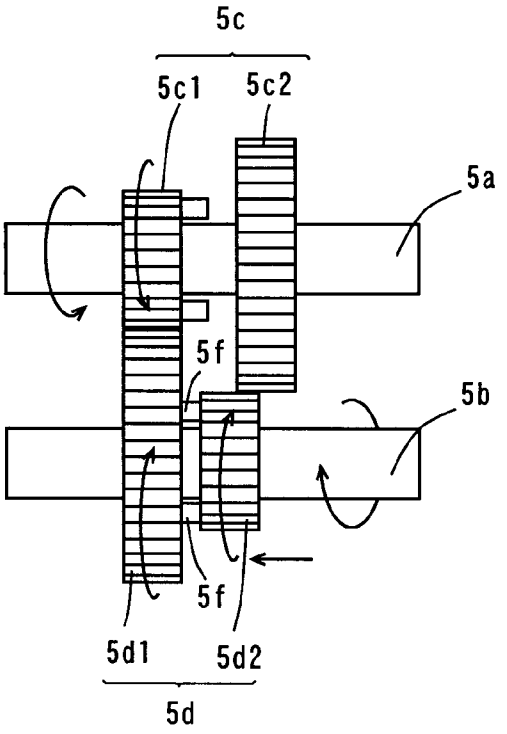


FIG. 3B



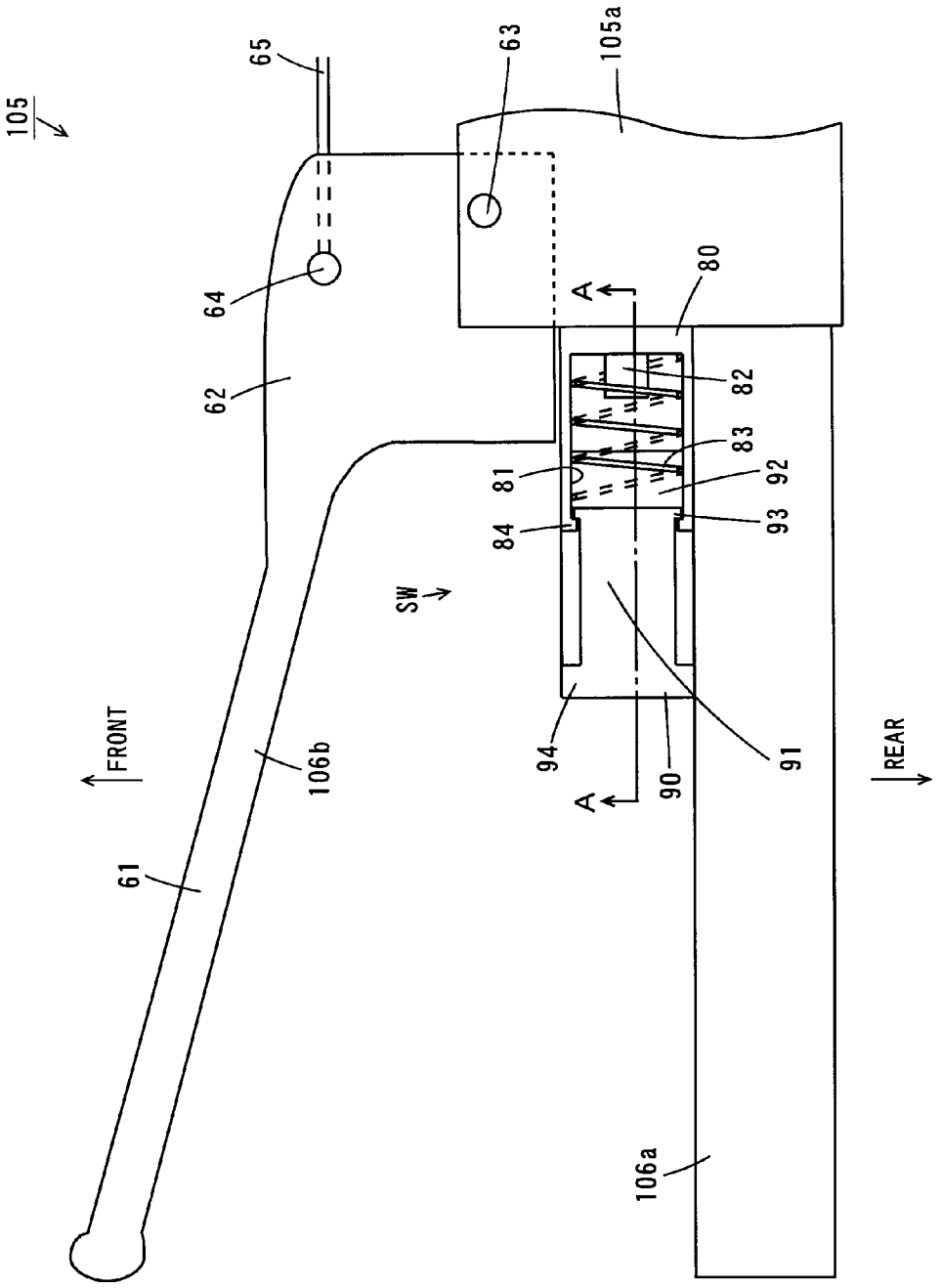

105
65
63
105a
64
62
80
82
83
81
92
93
84
SW
FRONT
106b
61
94
90
91
REAR
106a
A
A

FIG. 4

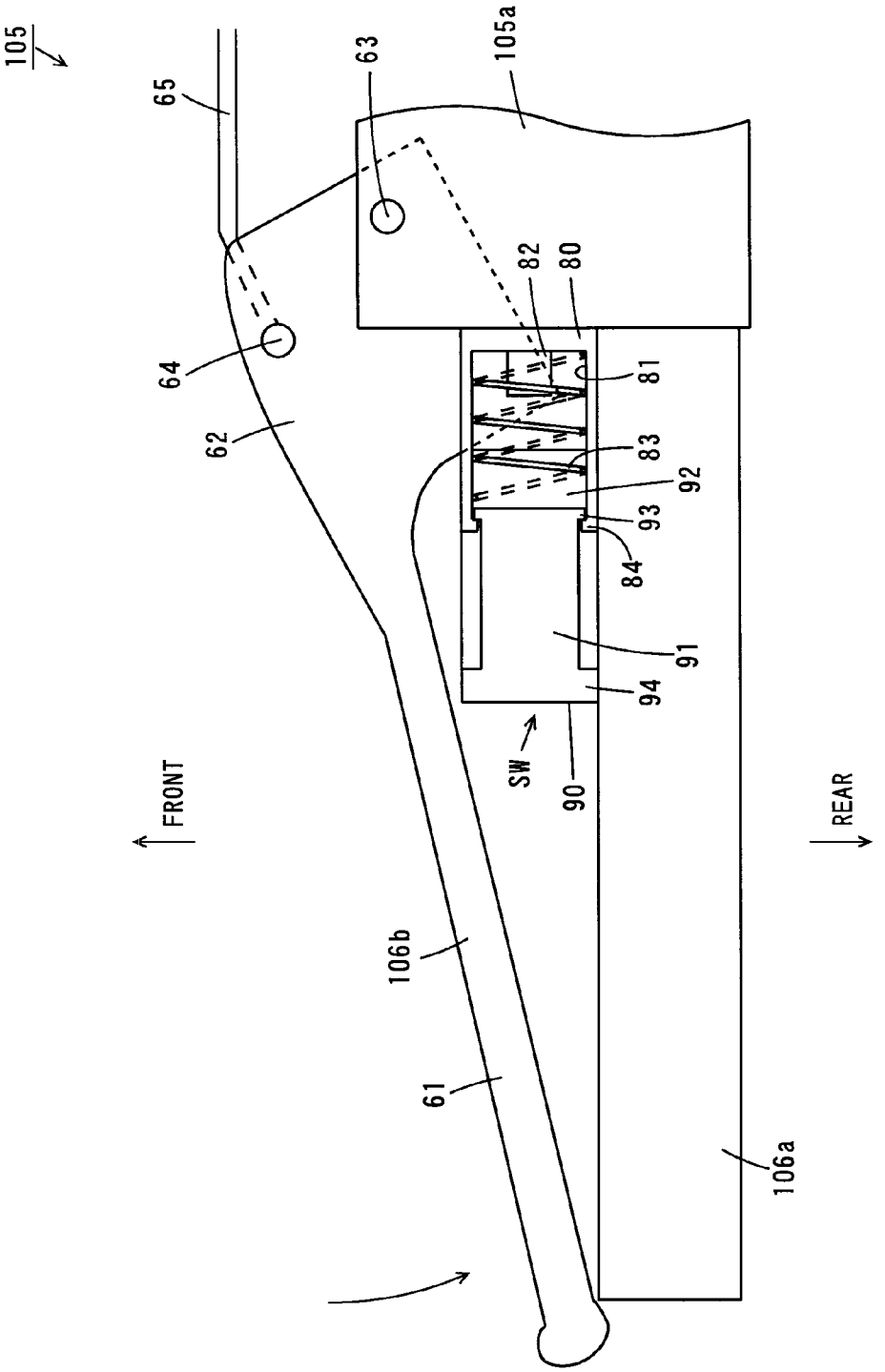

105
65
63
105a
82
80
64
81
62
83
92
93
84
91
94
SW
90
FRONT
REAR
106b
61
106a

FIG. 5

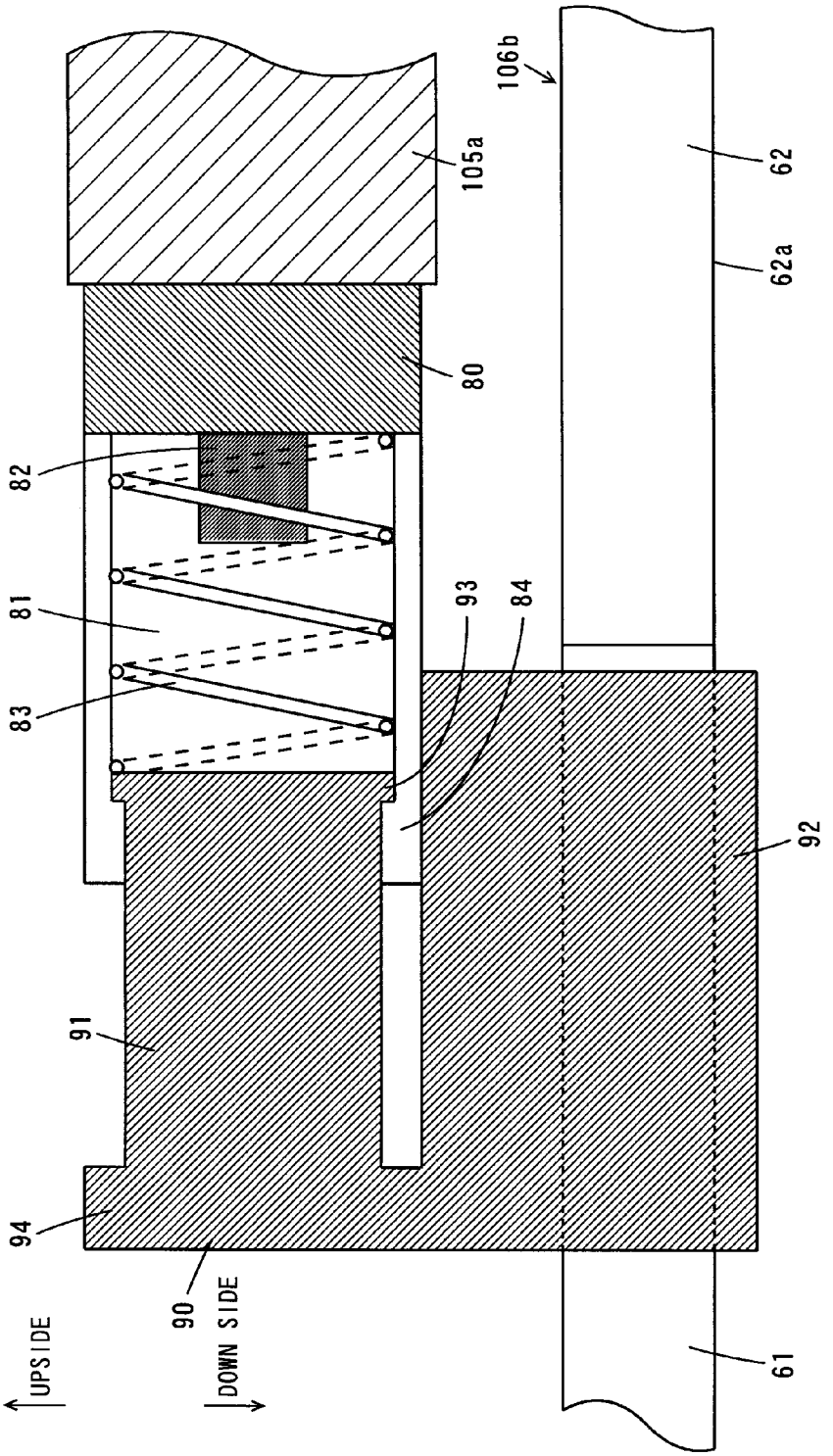


FIG. 6

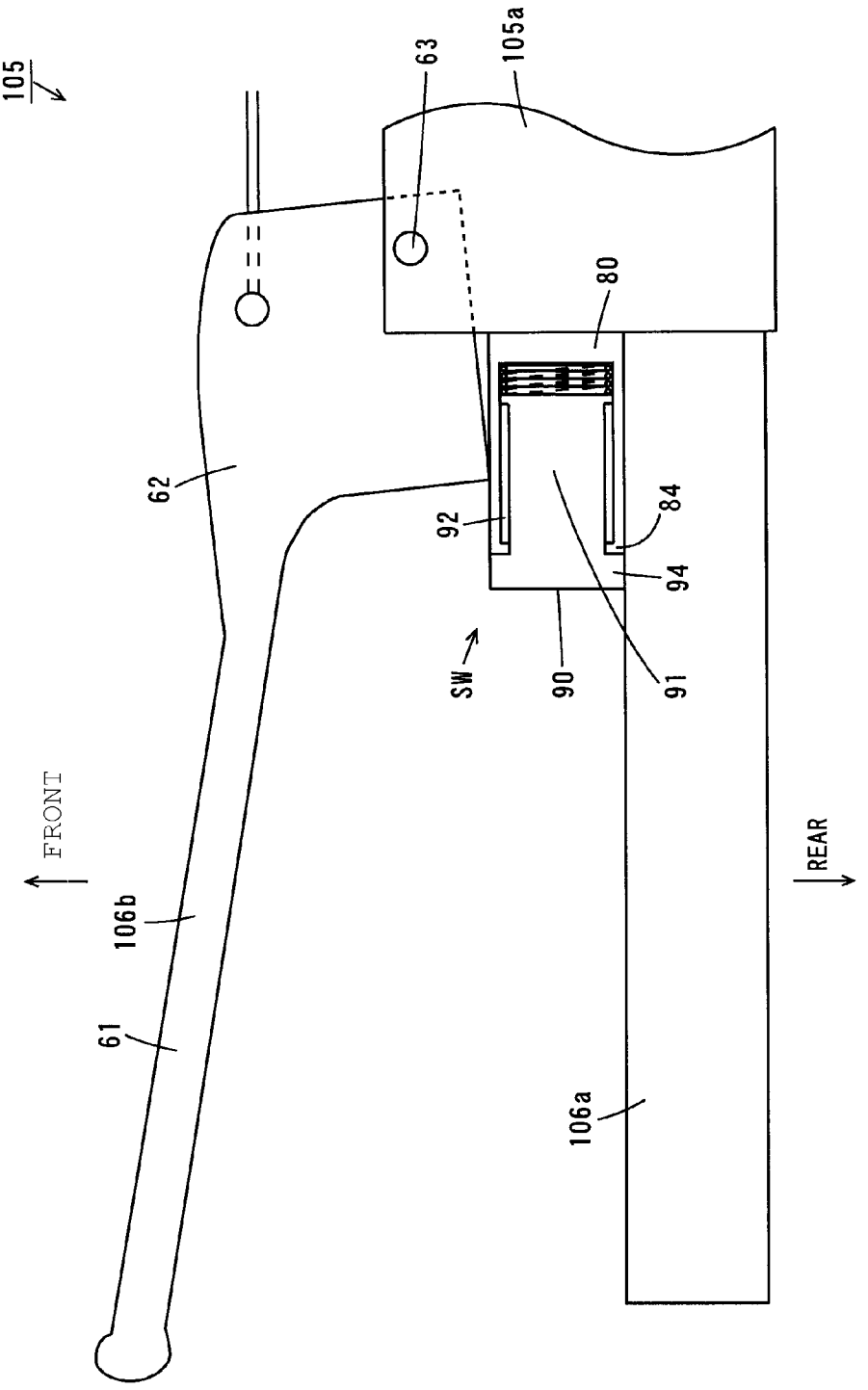


FIG. 7

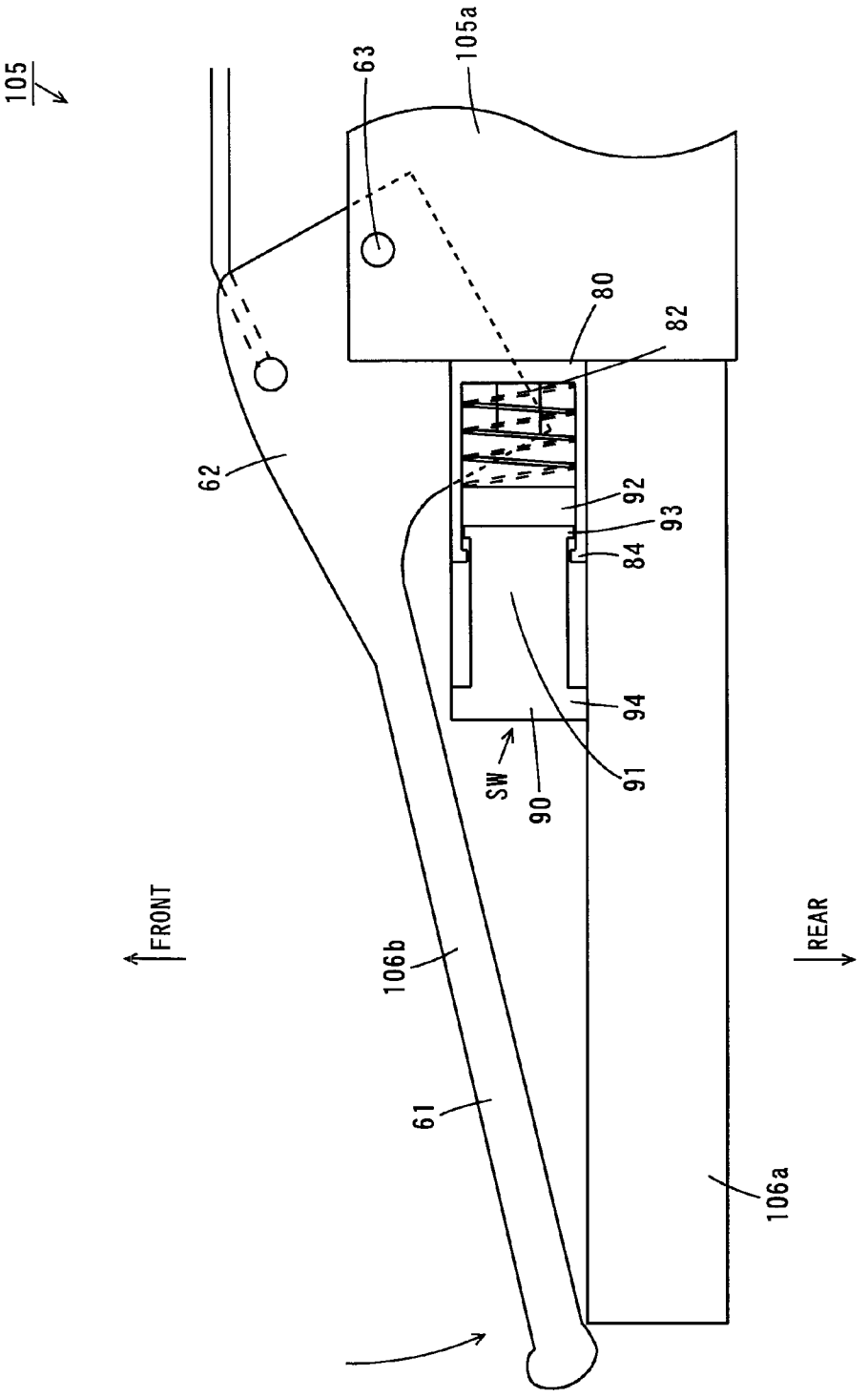


FIG. 8

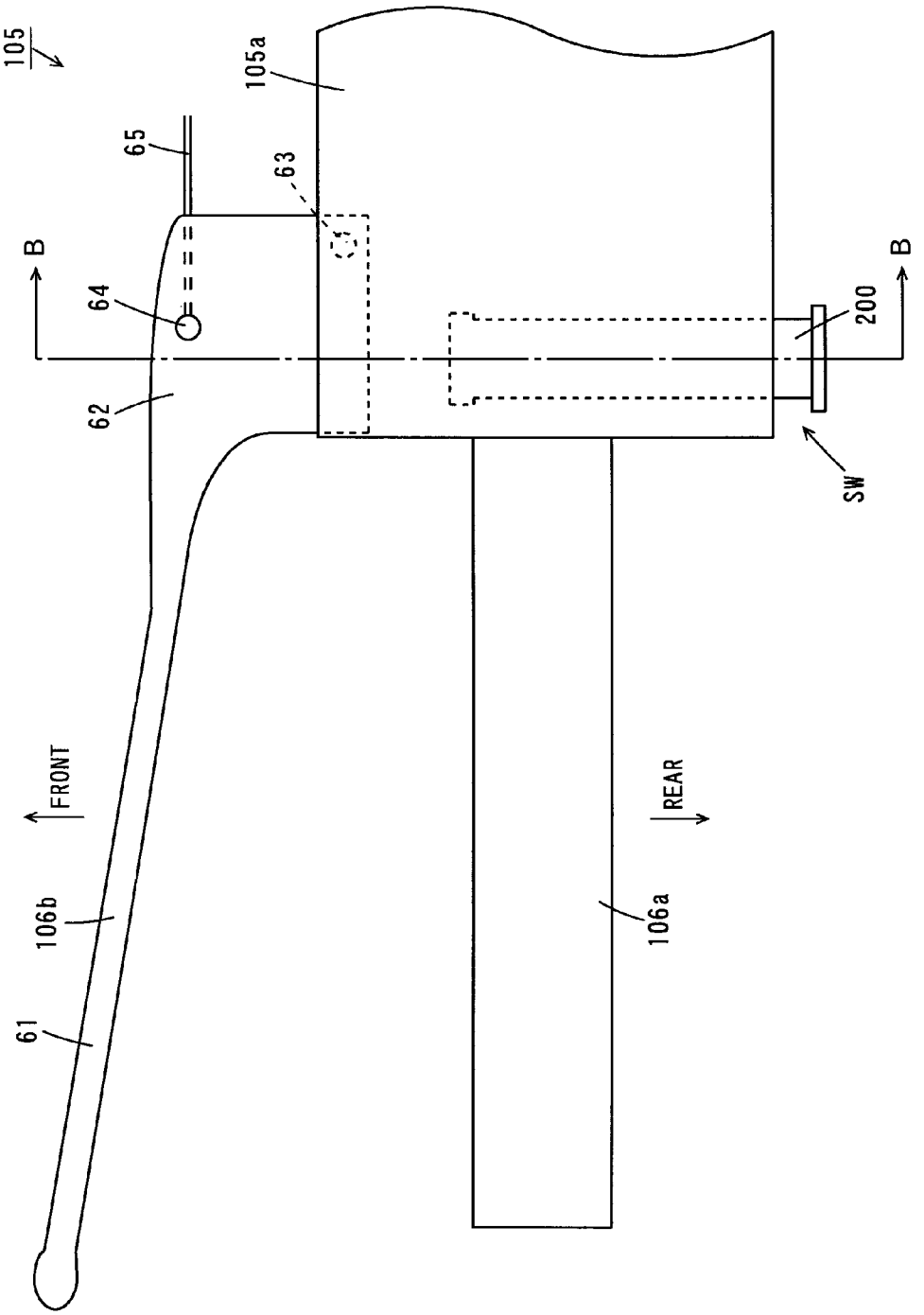


FIG. 9

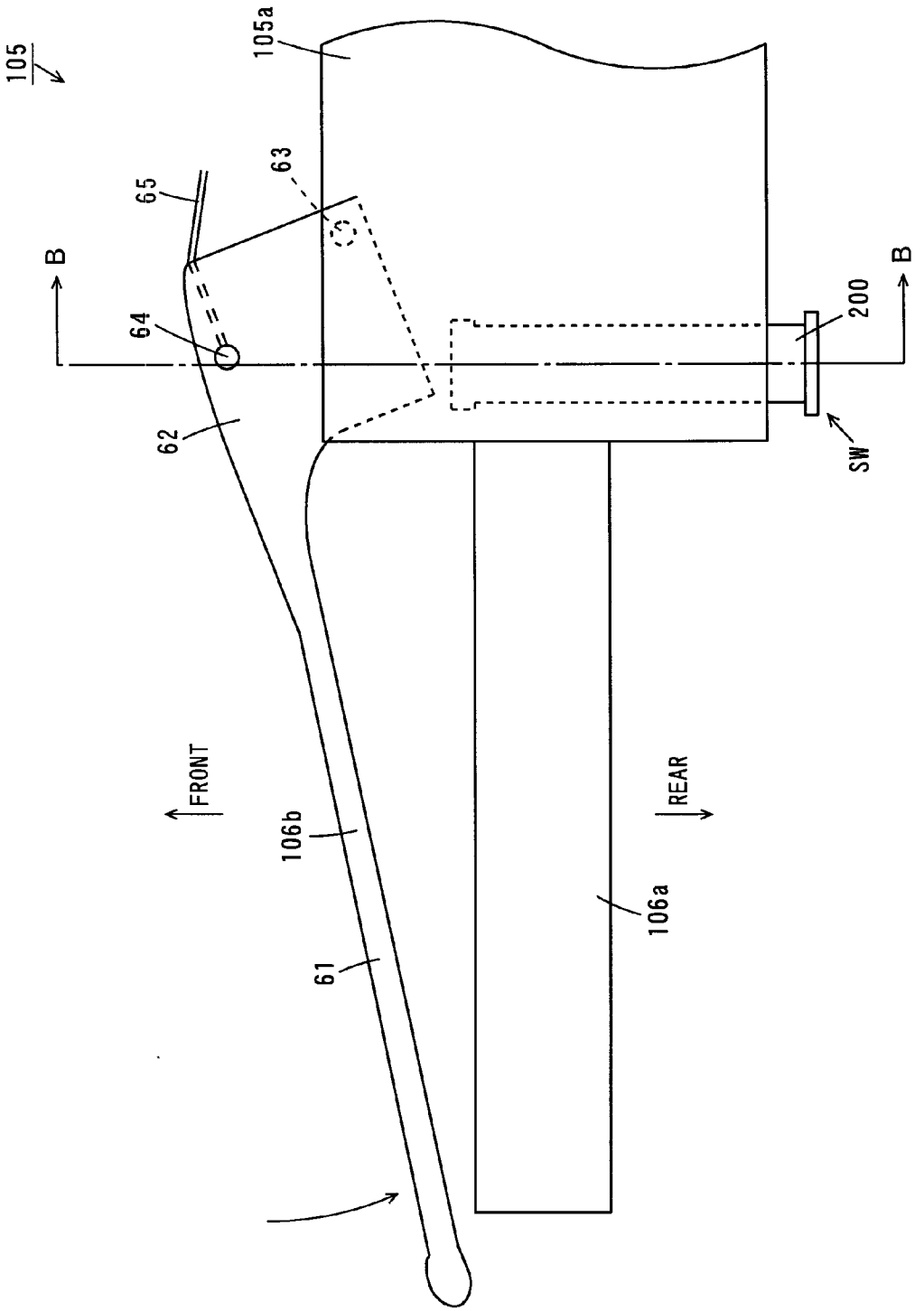


FIG. 10

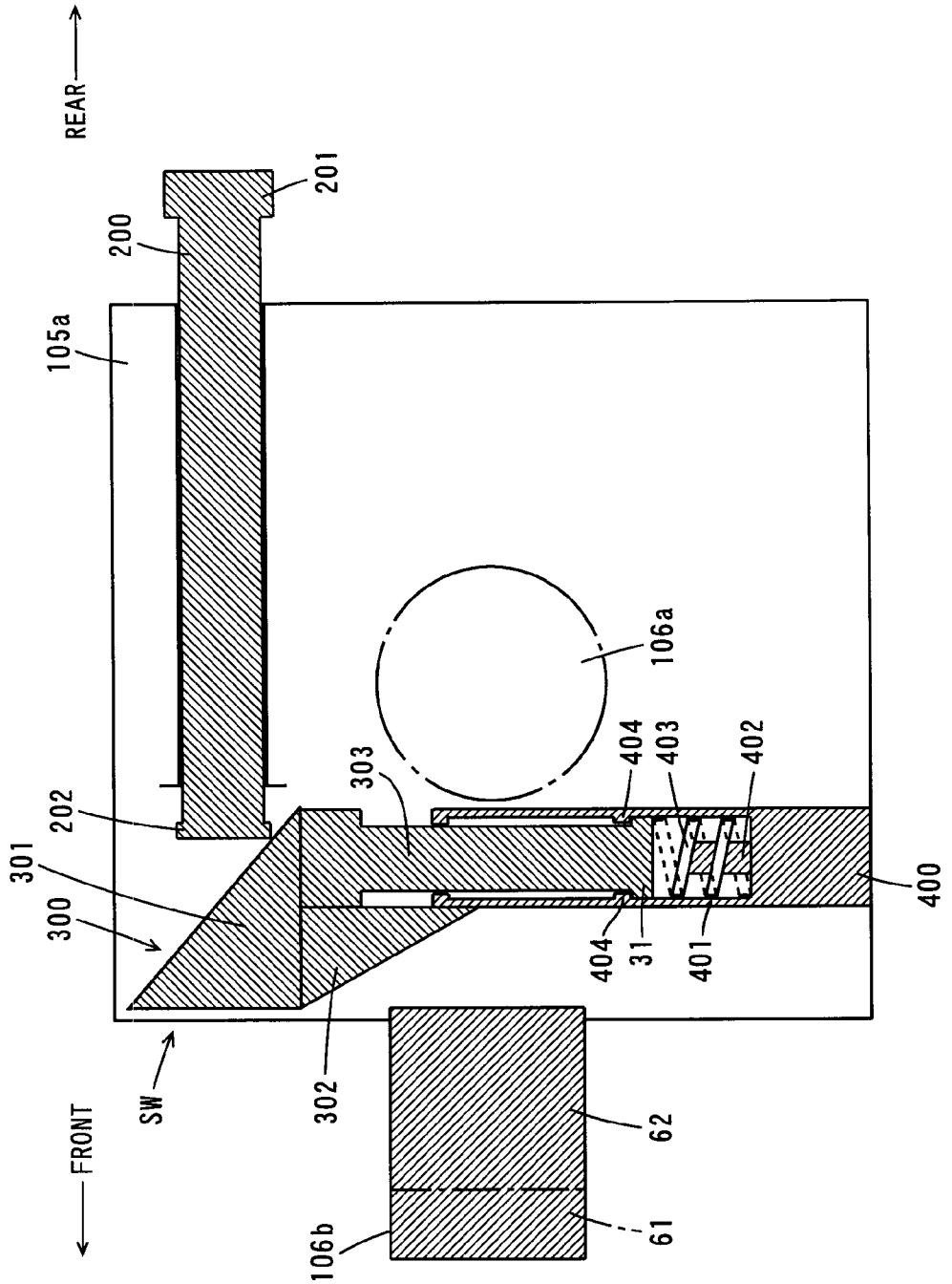

REAR
201
200
105a
106a
404
403
402
303
202
301
300
400
404
31
401
SW
302
62
FRONT
61
106b

FIG. 11

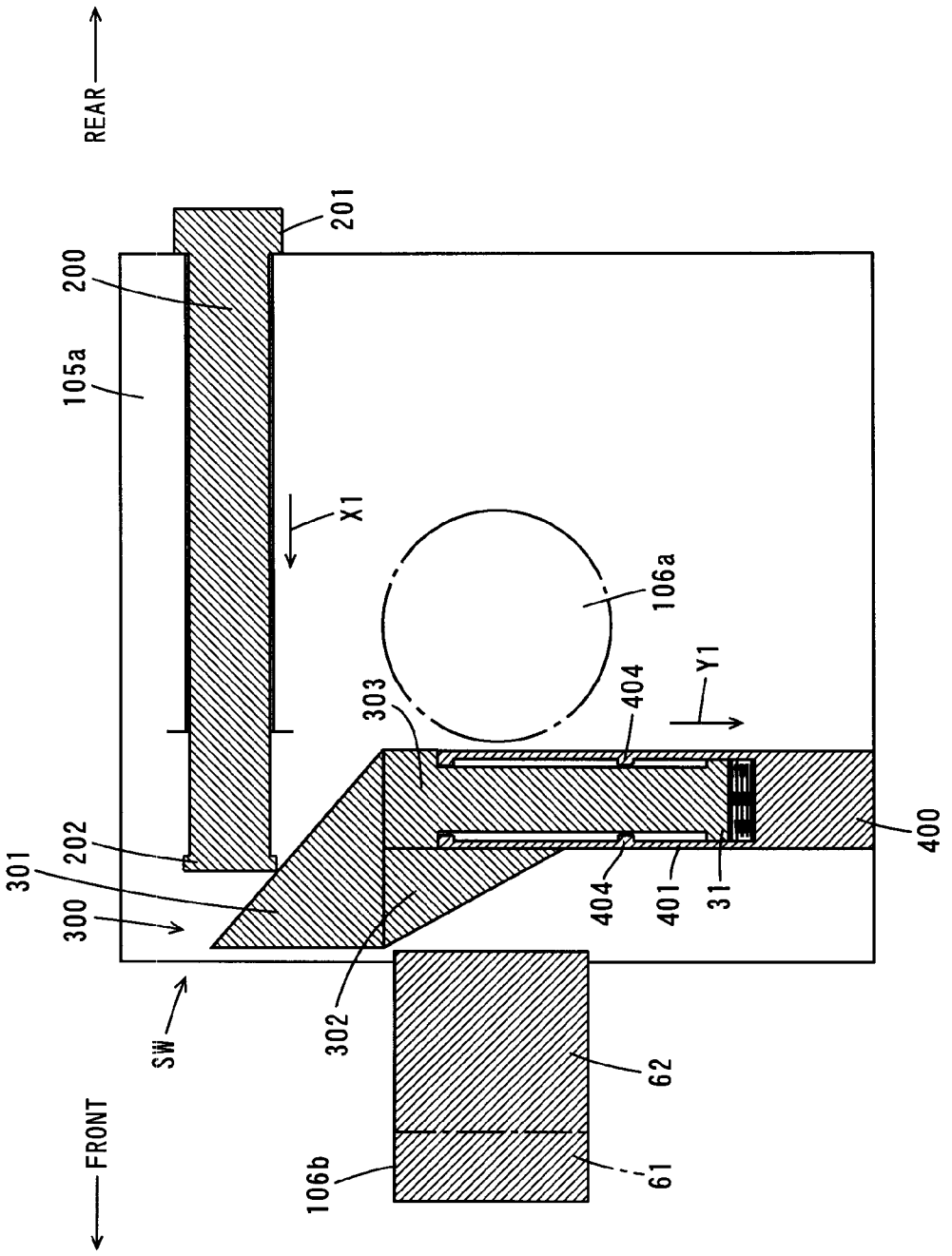

REAR
201
200
105a
X1
106a
303
404
Y1
400
301
202
300
404
401
31
SW
302
62
FRONT
106b
61

FIG. 12

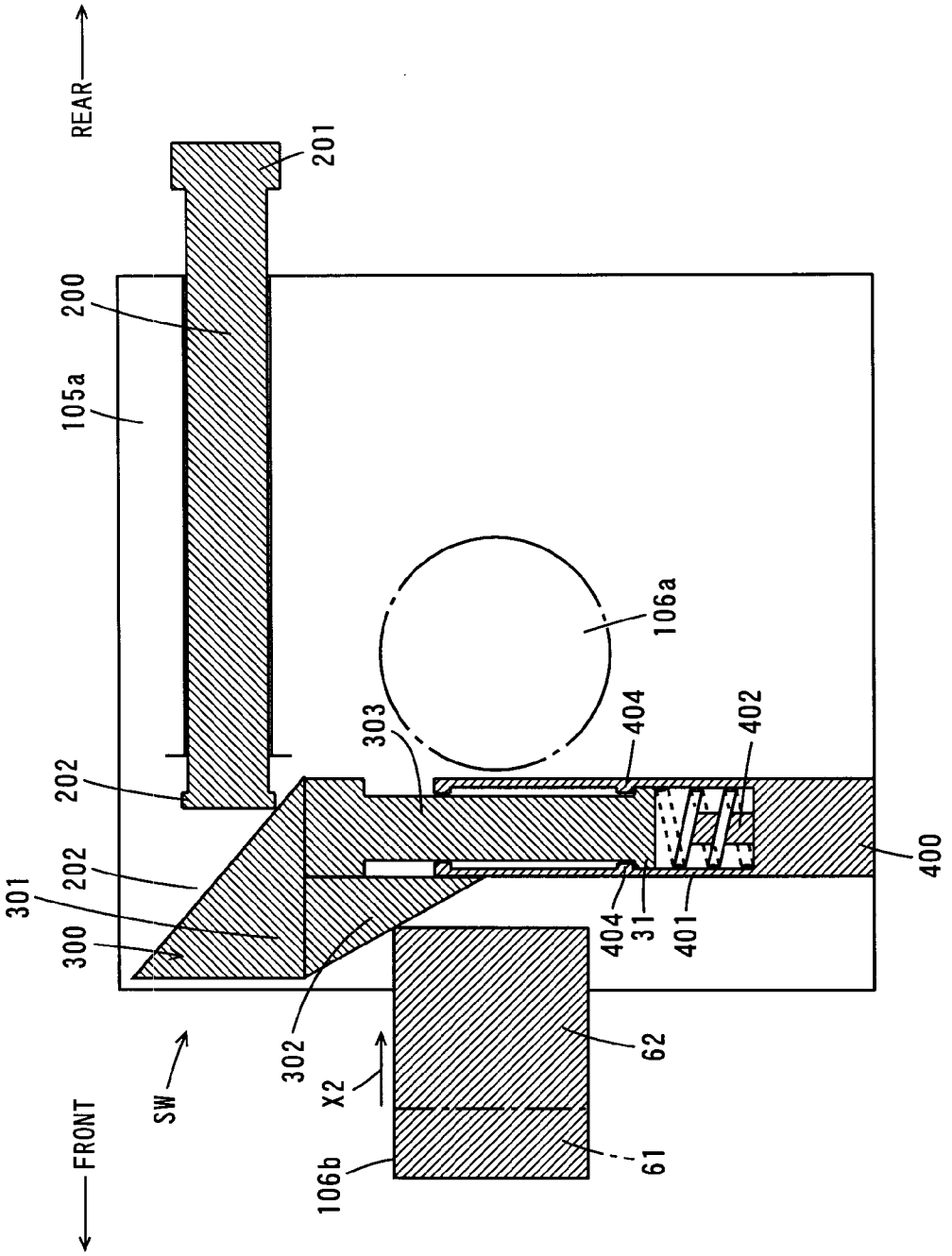

REAR
201
200
105a
106a
303
404
402
202
202
301
300
400
404
31
401
302
X2
62
SW
FRONT
106b
61

FIG. 13

FIG. 14A

DRIVING STATE

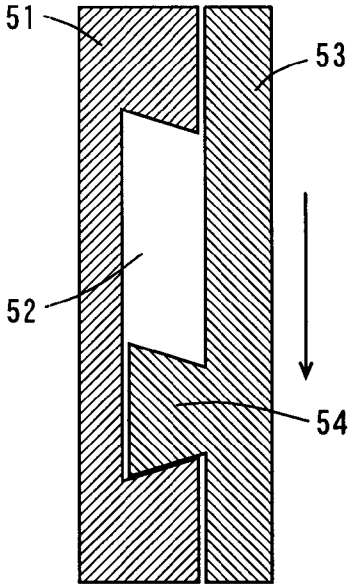


FIG. 14B

DRIVEN STATE

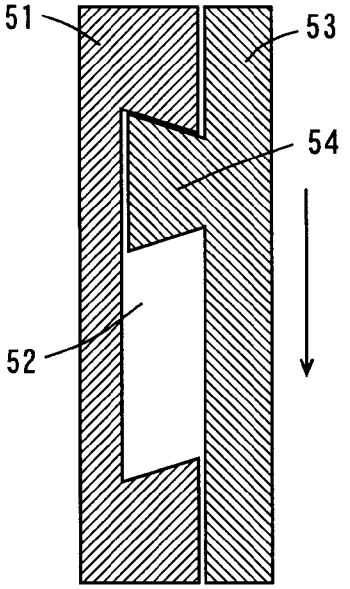


FIG. 14C

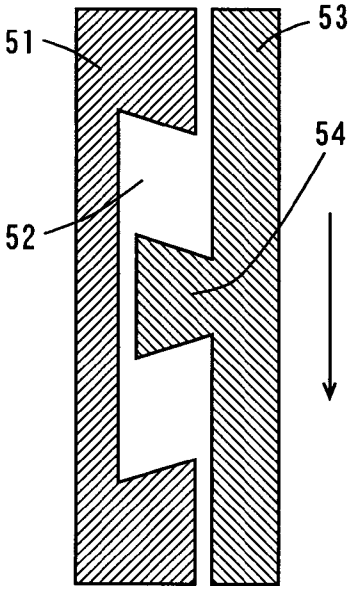


FIG. 15

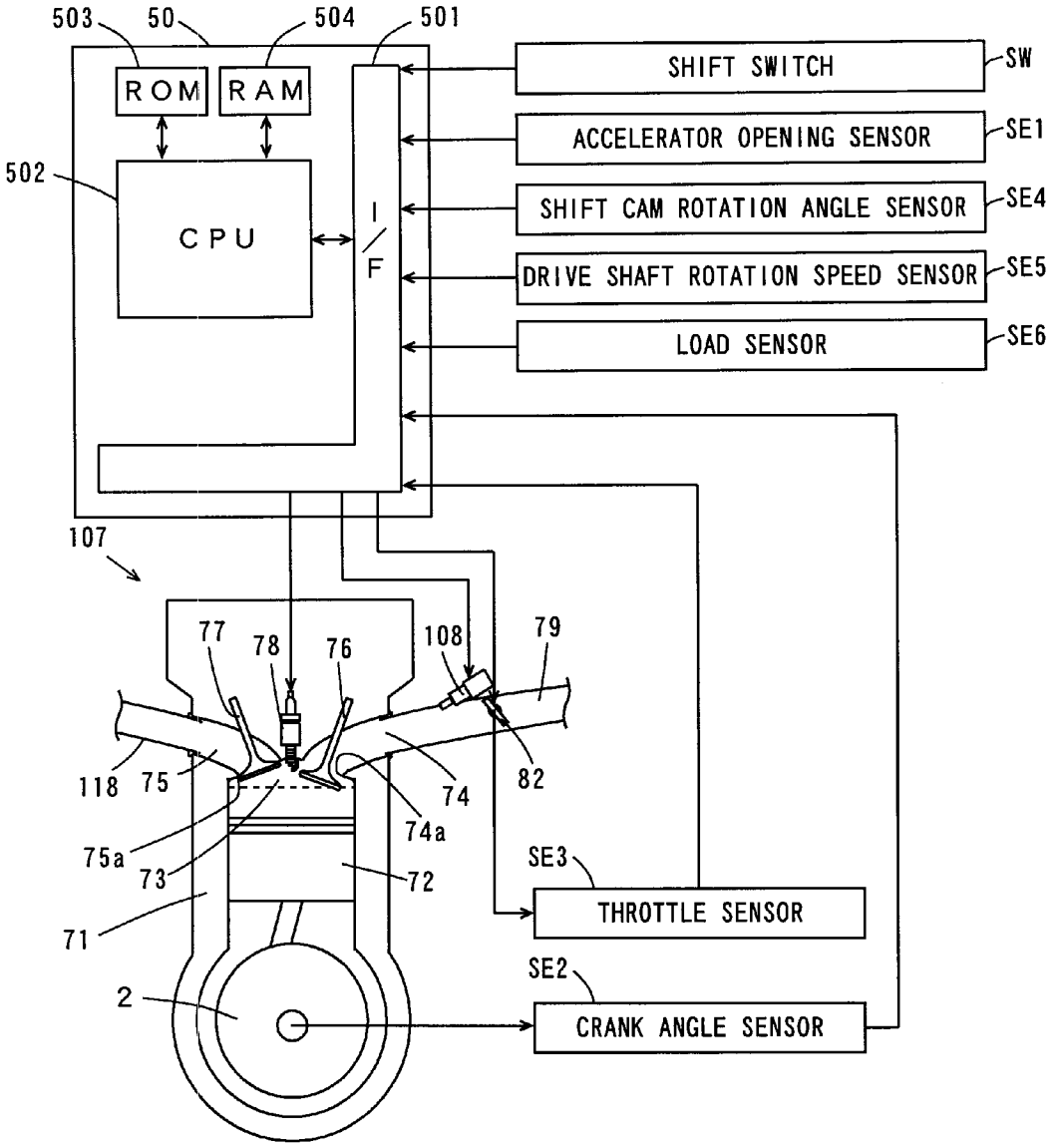
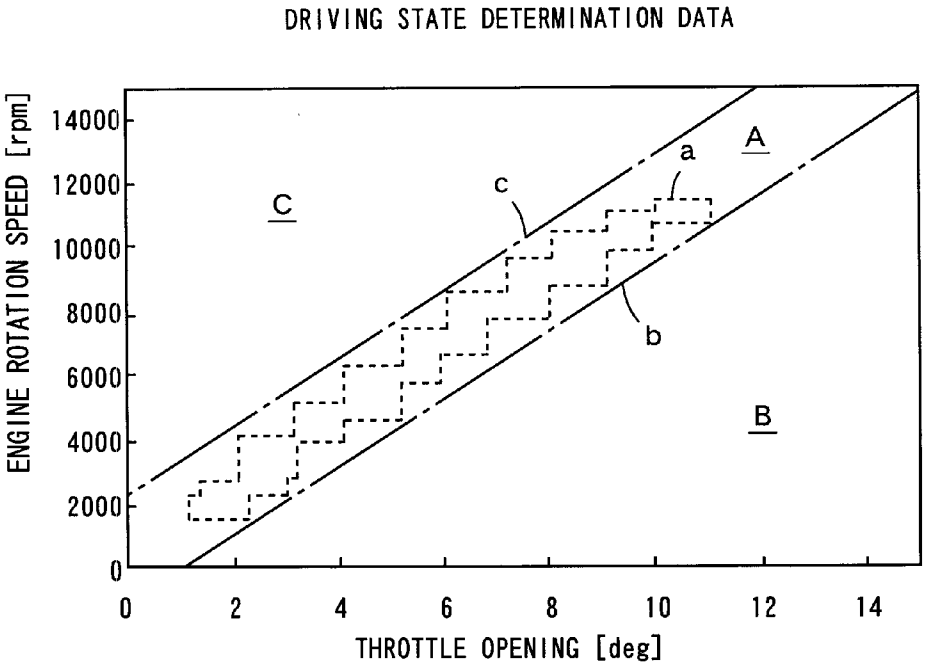

503
50
504
501
ROM
RAM
502
CPU
I/F
SHIFT SWITCH
SW
ACCELERATOR OPENING SENSOR
SE1
SHIFT CAM ROTATION ANGLE SENSOR
SE4
DRIVE SHAFT ROTATION SPEED SENSOR
SE5
LOAD SENSOR
SE6
107
77
78
76
108
79
118
75
74
82
74a
75a
73
72
71
SE3
THROTTLE SENSOR
SE2
2
CRANK ANGLE SENSOR

FIG. 16



A : BOUNDARY REGION

B : DRIVING REGION

C : DRIVEN REGION

FIG. 17A

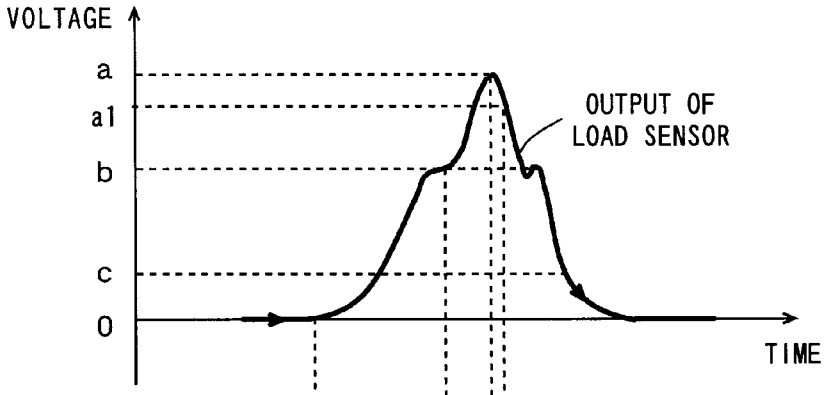


FIG. 17B

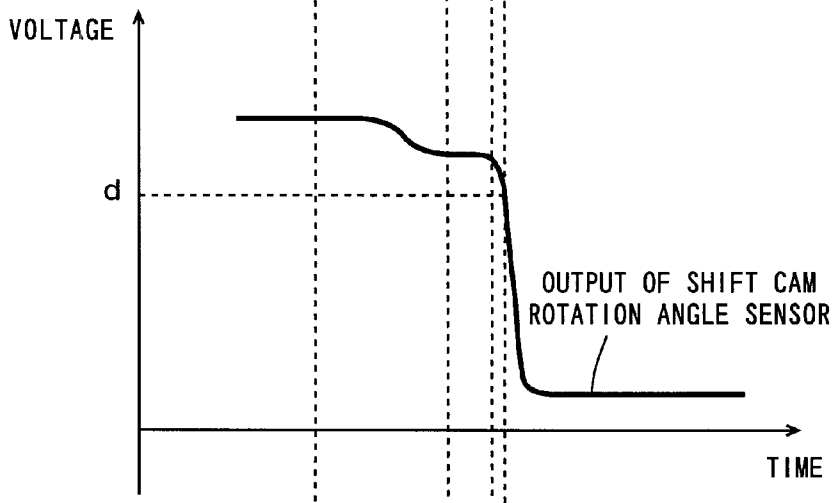


FIG. 17C

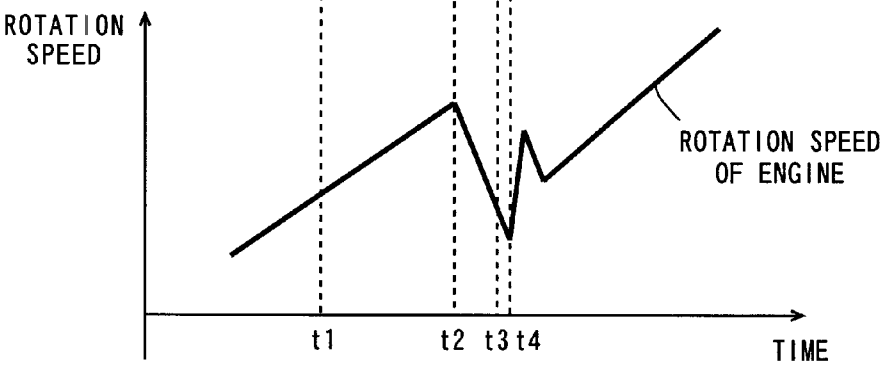


FIG. 18A

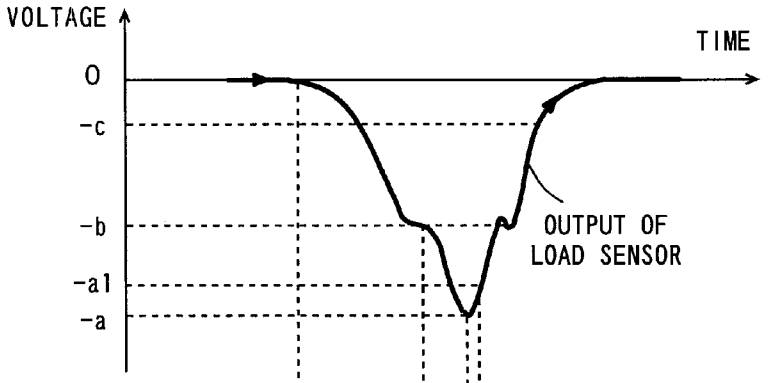


FIG. 18B

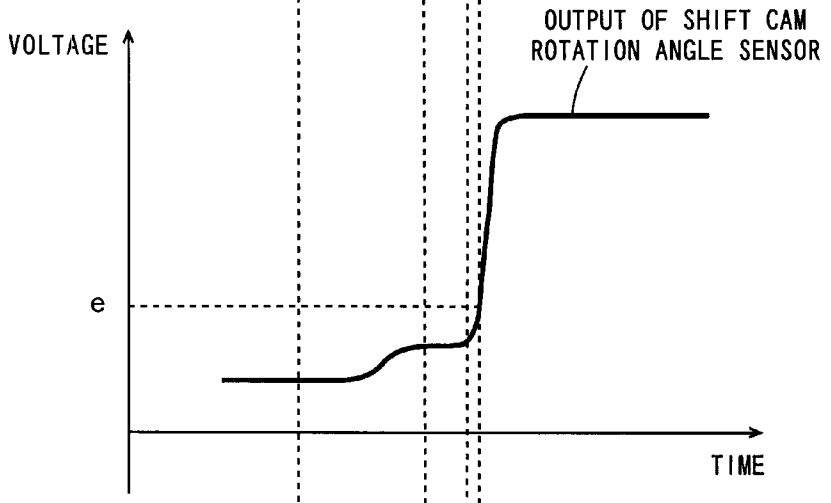


FIG. 18C

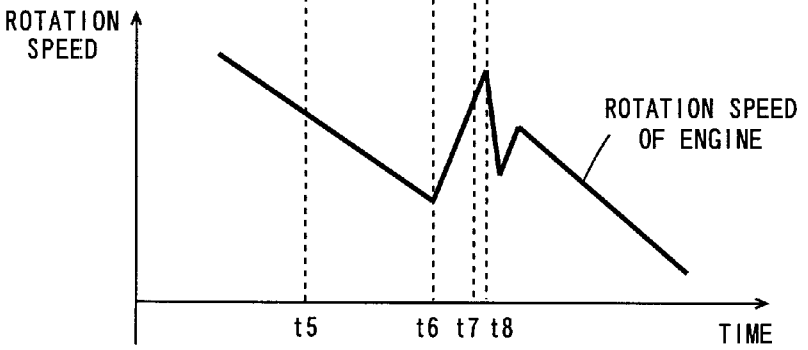


FIG. 19

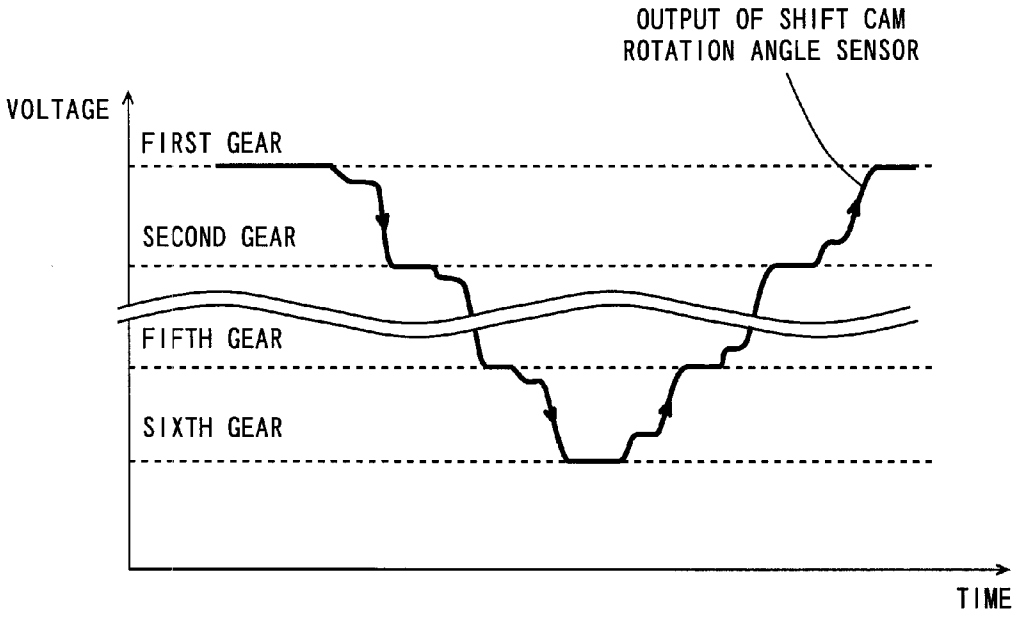

OUTPUT OF SHIFT CAM
ROTATION ANGLE SENSOR
VOLTAGE
FIRST GEAR
SECOND GEAR
FIFTH GEAR
SIXTH GEAR
TIME

FIG. 20

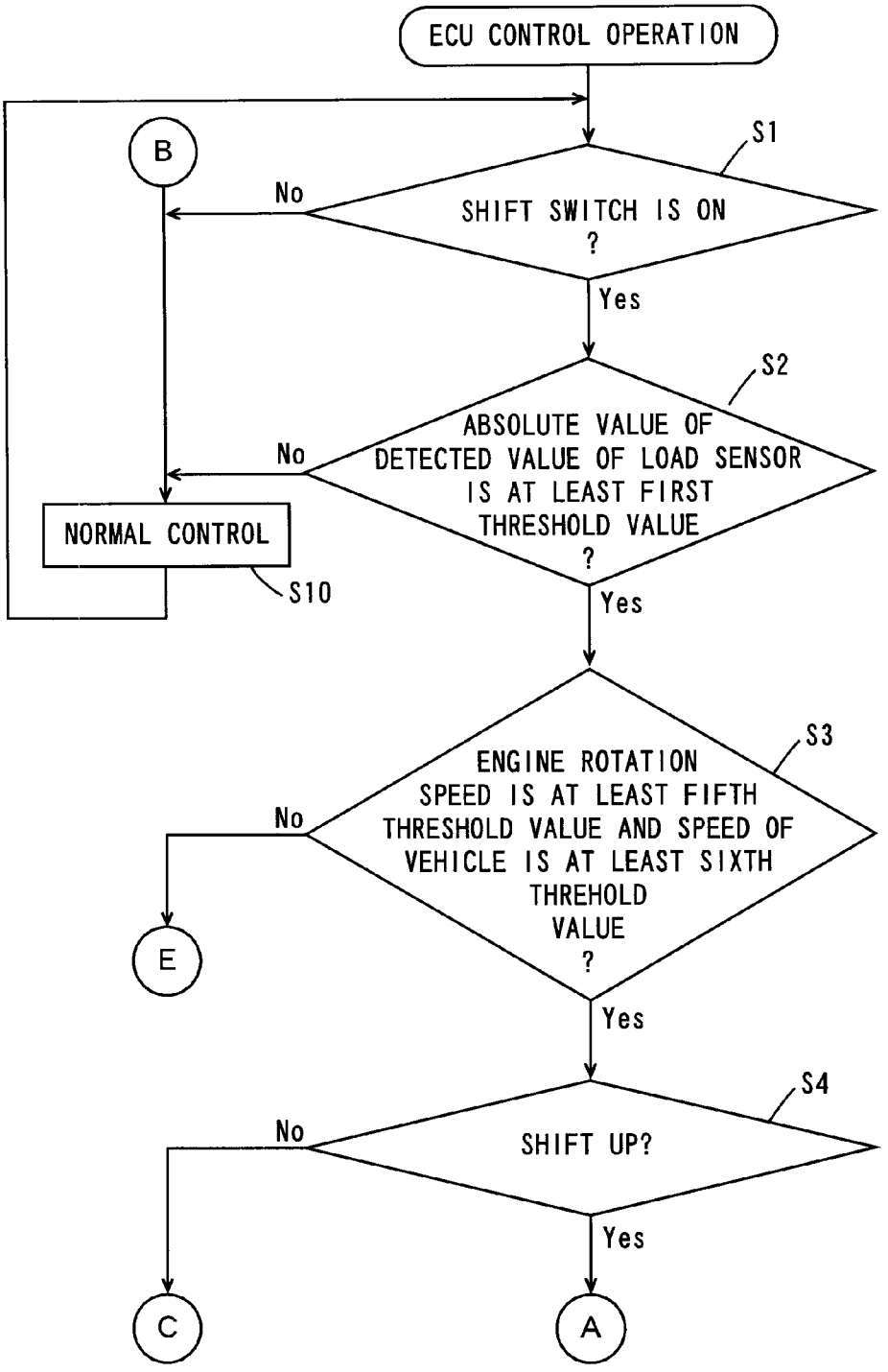

ECU CONTROL OPERATION
B
S1
No
SHIFT SWITCH IS ON ?
Yes
S2
No
ABSOLUTE VALUE OF DETECTED VALUE OF LOAD SENSOR IS AT LEAST FIRST THRESHOLD VALUE ?
NORMAL CONTROL
S10
Yes
S3
No
ENGINE ROTATION SPEED IS AT LEAST FIFTH THRESHOLD VALUE AND SPEED OF VEHICLE IS AT LEAST SIXTH THREHOLD VALUE ?
E
Yes
S4
No
SHIFT UP?
Yes
C
A

FIG. 21

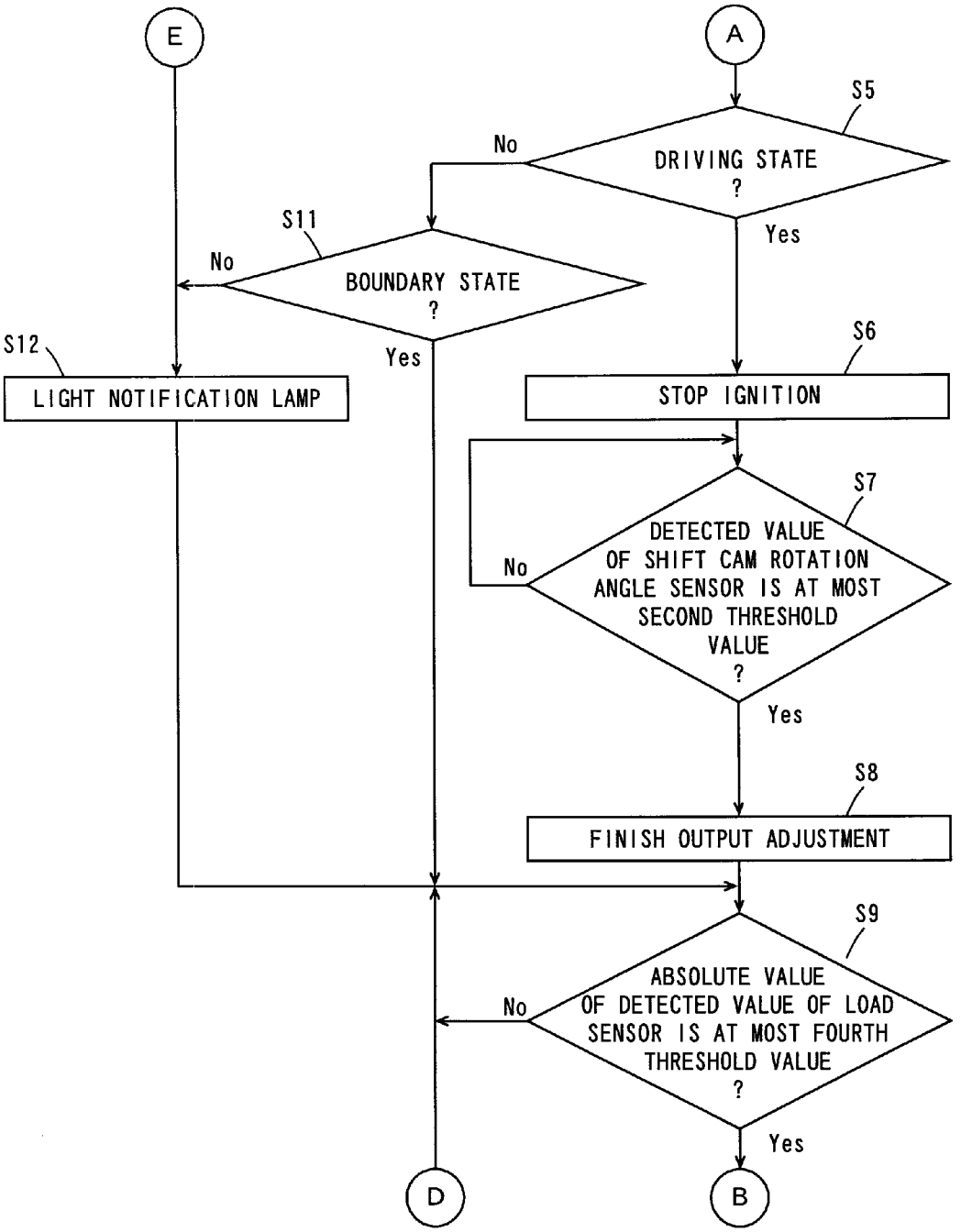
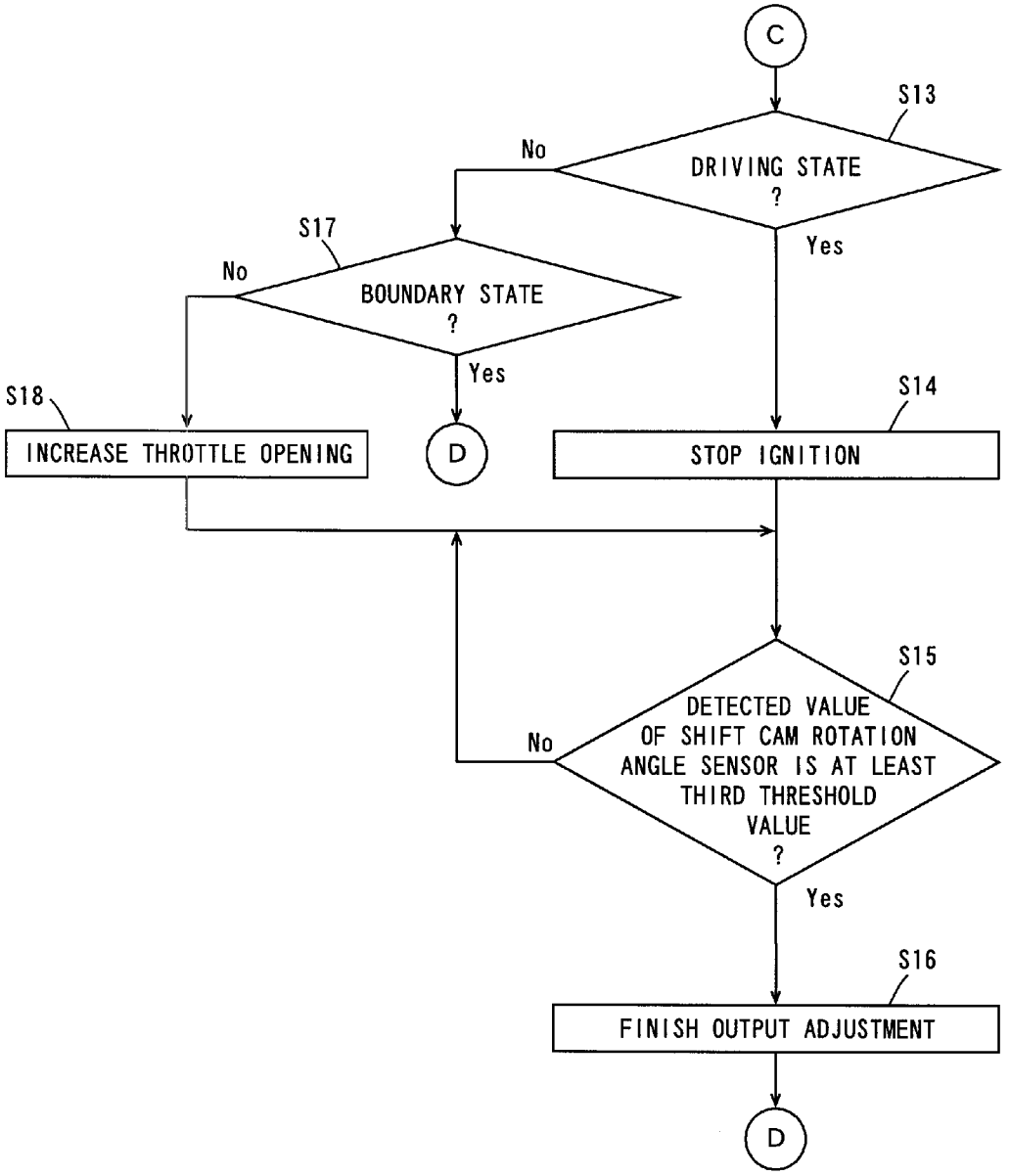

E
A
S5
DRIVING STATE ?
No
Yes
S11
BOUNDARY STATE ?
No
Yes
S12
LIGHT NOTIFICATION LAMP
S6
STOP IGNITION
S7
DETECTED VALUE OF SHIFT CAM ROTATION ANGLE SENSOR IS AT MOST SECOND THRESHOLD VALUE ?
No
Yes
S8
FINISH OUTPUT ADJUSTMENT
S9
ABSOLUTE VALUE OF DETECTED VALUE OF LOAD SENSOR IS AT MOST FOURTH THRESHOLD VALUE ?
No
Yes
D
B

FIG. 22


C
S13
DRIVING STATE ?
No
Yes
S17
BOUNDARY STATE ?
No
Yes
S18
INCREASE THROTTLE OPENING
D
S14
STOP IGNITION
S15
DETECTED VALUE OF SHIFT CAM ROTATION ANGLE SENSOR IS AT LEAST THIRD THRESHOLD VALUE ?
No
Yes
S16
FINISH OUTPUT ADJUSTMENT
D

ENGINE OUTPUT ADJUSTMENT SYSTEM AND VEHICLE INCLUDING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an engine output adjustment system that assists a shift operation of a transmission and a vehicle including the same.

[0003] 2. Description of the Related Art

[0004] When operating a gearshift in a vehicle with a manual transmission, first, a driver usually disconnects a clutch. Thus, power transmission from a crankshaft of an engine to a main shaft of the transmission is stopped, so that gears are easily disconnected. In this state, the driver performs a shift operation and changes gear positions. Finally, the driver connects the clutch, so that the power is transmitted from the crankshaft to the main shaft. In this way, the gearshift operation is completed.

[0005] During a race or other high speed activities, the gearshift is required to be operated quickly. Therefore, in some situations, the driver operates the gearshift without a clutch operation (hereinafter referred to as "clutchless shifting"). In such situations, since the gearshift is operated while the power is being transmitted from the crankshaft to the main shaft, it is difficult to disconnect the gears. Thus, the driver must adjust an output of the engine so that the gears can be easily disconnected.

[0006] The adjustment of the output of the engine, described above, is a difficult operation for a less skilled driver. Therefore, if the less skilled driver performs the clutchless shifting, in some cases, the gearshift cannot be performed smoothly.

[0007] Conventionally, a device that controls the output of the engine during the clutchless shifting has been developed (see JP 6-146941 A, for example).

[0008] In the engine output control device disclosed in JP 6-146941 A, when a driver performs a shift operation, the ignition timing of an engine is retarded by an ignition control device. This causes a driving force exerted between a gear on the output shaft side of a transmission and a gear on the input shaft side thereof to be reduced. As a result, the driver can perform a smooth shift operation.

[0009] Furthermore, the above-mentioned engine output control device is provided with a manual ON-OFF switch. The control of the ignition timing by the ignition control device can be inhibited by operating the ON-OFF switch. This makes it possible to choose whether or not the output of the engine is controlled depending on the situation.

[0010] When the clutch is disconnected while the output of the engine is adjusted by the ignition control device, a difference may, in some cases, arise between the numbers of revolutions of the crank shaft on the side of the engine and the main shaft on the side of the transmission. In this case, when the clutch is connected again, a shock is generated in a vehicle, so that a driving feeling may be negatively impacted.

[0011] In the above-mentioned structure of the engine output control device, the driver can easily operate a clutch lever while the output of the engine is adjusted by the ignition control device. Consequently, the driver may erroneously disconnect the clutch without noticing that the output of the engine is controlled by the ignition control device. In this case, a shock that is not expected by the driver is generated in the vehicle when the driver connects the clutch, so that the driving feeling of the vehicle is worsened.

SUMMARY OF THE INVENTION

[0012] In order to overcome the problems described above, preferred embodiments of the present invention provide an engine output adjustment system that enables comfortable driving of a vehicle and a vehicle including the same.

[0013] According to a preferred embodiment of the present invention, an engine output adjustment system that adjusts an output of an engine in a vehicle that transmits a torque generated by the engine to a drive wheel through a clutch and a transmission includes an engine output adjuster that adjusts the output of the engine when a driver performs a shift operation of the transmission, and an inhibiting mechanism that inhibits the clutch from being disconnected by the driver when the output of the engine is adjusted by the engine output adjuster.

[0014] According to the engine output adjustment system, the output of the engine is adjusted when the driver performs the shift operation of the transmission. Thus, an engaging force of a gear on the input shaft side of the transmission with a gear on the output shaft side thereof is decreased, so that the gears can be easily moved away from each other. As a result, the driver can easily perform clutchless shifting.

[0015] When the output of the engine is adjusted by the engine output adjuster, the inhibiting mechanism inhibits the clutch from being disconnected by the driver. In this case, the clutch can be prevented from being disconnected by the driver while the output of the engine is adjusted by the engine output adjuster. This can prevent an unexpected shock from being generated in the vehicle during the shift operation. The results can prevent the driving feeling of the vehicle from being negatively impacted.

[0016] Furthermore, since the inhibiting mechanism inhibits the clutch from being disconnected, the driver can easily recognize that the output of the engine is adjusted by the engine output adjuster. Even when the driver tries to erroneously disconnect the clutch while the output of the engine is adjusted, the driver can immediately interrupt the operation. This can reliably prevent the driving feeling of the vehicle from being decreased.

[0017] The results described above enable comfortable driving of the vehicle.

[0018] The inhibiting mechanism may preferably inhibit the output of the engine from being adjusted by the engine output adjuster when the driver disconnects the clutch.

[0019] In this case, the output adjustment of the engine can be prevented from being performed by the engine output adjuster with the clutch disconnected. This can prevent an unexpected shock from being generated in the vehicle in the clutch connection. The results enable comfortable driving of the vehicle.

[0020] The inhibiting mechanism may either enable the engine output adjuster to adjust the output of the engine or enable the driver to disconnect the clutch.

[0021] In this case, it is possible to prevent the output adjustment of the engine by the engine output adjuster and the disconnection of the clutch by the driver from being simultaneously performed. This can reliably prevent an unexpected shock from being generated in the vehicle.

[0022] The engine output adjustment system may further include a switch mechanism operated by the driver, and the engine output adjuster may adjust the output of the engine

when the switch mechanism is operated and the shift operation of the transmission is performed.

[0023] In this case, in order to adjust the output of the engine by the engine output adjuster, the driver must perform two operations, i.e., the operation of the switch mechanism and the shift operation. This can prevent the output of the engine from being adjusted by the engine output adjuster against the will of the driver.

[0024] The engine output adjustment system may further include a clutch operating member operated by the driver for operating the clutch, and the inhibiting mechanism may inhibit the clutch operating member from being operated by the driver when the driver operates the switch mechanism.

[0025] In this case, even when the driver tries to erroneously operate the clutch operating member with the output of the engine adjusted by the engine output adjuster, the clutch can be prevented from being disconnected. This can prevent the clutch from being disconnected while the output of the engine is adjusted by the engine output adjuster. Since the clutch operation is inhibited from being performed by the driver, the driver can immediately interrupt the operation. There results can more reliably prevent the driving feeling of the vehicle from being negatively impacted.

[0026] The inhibiting mechanism may inhibit the switch mechanism from being operated by the driver when the driver operates the clutch operating member.

[0027] In this case, even when the driver tries to erroneously operate the switch mechanism during the clutch operation, the switch mechanism can be prevented from being operated. This can prevent the output of the engine from being adjusted with the clutch disconnected. Since the switch mechanism is inhibited from being operated by the driver, the driver can immediately interrupt the operation. These results can sufficiently prevent the driving feeling of the vehicle from being worsened.

[0028] The inhibiting mechanism may include the switch mechanism and the clutch operating member, the switch mechanism may include a first moving portion that moves in synchronization with the operation by the driver, the clutch operating member may include a second moving portion that moves in synchronization with the operation by the driver, the first moving portion may move to a position where the second moving portion is inhibited from moving when the driver operates the switch mechanism, and the second moving portion may move to a position where the first moving portion is inhibited from moving when the driver operates the clutch operating member.

[0029] In this case, when the driver operates the switch mechanism, the first moving portion in the switch mechanism inhibits the second moving portion in the clutch operating member from moving. Even when the driver tries to erroneously operate the clutch operating member with the output of the engine adjusted by the engine output adjuster, therefore, the clutch can be prevented from being disconnected. This can prevent the clutch from being disconnected while the output of the engine is adjusted by the engine output adjuster. Since the clutch operation is inhibited from being performed by the driver, the driver can immediately interrupt the operation. These results can sufficiently prevent the driving feeling of the vehicle from being worsened.

[0030] Furthermore, when the driver operates the clutch operating member, the second moving portion in the clutch operating member inhibits the first moving portion in the switch mechanism from moving. Even when the driver tries to erroneously operate the switch mechanism during the clutch operation, therefore, the switch mechanism can be prevented from being operated. This can prevent the output of the engine from being adjusted with the clutch disconnected. Since the switch mechanism is inhibited from being operated by the driver, the driver can immediately interrupt the operation. These results can reliably prevent the driving feeling of the vehicle from being negatively impacted.

[0031] The inhibiting mechanism may include the switch mechanism and the clutch operating member, the switch mechanism may include a third moving portion that moves in a first direction in synchronization with the operation by the driver, the clutch operating member may include a fourth moving portion that moves in a second direction in synchronization with the operation by the driver, the third moving portion may urge the fourth moving portion in a direction opposite to the second direction when the driver operates the switch mechanism, and the fourth moving portion may urge the third moving portion in a direction opposite to the first direction when the driver operates the clutch operating member.

[0032] In the engine output adjustment system, the driver moves the third moving portion in the switch mechanism in the first direction when operating the switch mechanism. Further, the driver moves the fourth moving portion in the clutch operating member in the second direction when operating the clutch operating member.

[0033] Here, when the driver operates the switch mechanism, the third moving portion in the switch mechanism causes the fourth moving portion in the clutch operating member to be urged in the opposite direction to the second direction. Even when the driver tries to erroneously operate the clutch operating member with the output of the engine adjusted by the engine output adjuster, therefore, the driver can immediately interrupt the operation.

[0034] When the driver operates the clutch operating member, the fourth moving portion in the clutch operating member causes the third moving portion in the switch mechanism to be urged in the opposite direction to the first direction. Even when the driver tries to erroneously operate the switch mechanism during the clutch operation, therefore, the driver can immediately interrupt the operation.

[0035] The results described above can sufficiently prevent the driving feeling of the vehicle from being negatively impacted.

[0036] When the driver performs the shift operation of the transmission, the engine output adjuster may decrease the output of the engine when the torque is at least a first value in a driving state where it is transmitted from the engine to the transmission and may not decrease the output when the torque is less than the first value in the driving state.

[0037] In this case, when the torque is at least the first value when the driver performs the shift operation in the driving state, the output of the engine is decreased. Thus, the torque is transmitted between the input shaft and the output shaft of the transmission to be reduced, so that the engaging force of the gear on the input shaft side of the transmission with the gear on the output shaft side thereof is reduced. As a result, the gear on the input shaft side of the transmission and the gear on the output shaft side thereof can be easily moved away from each other, which enables the driver to easily perform the clutchless shifting.

[0038] Furthermore, when the torque is less than the first value in the driving state, the output of the engine is not

decreased. Here, when the torque is less than the first value in the driving state, the torque transmitted between the input shaft and the output shaft of the transmission is small. In this case, no great engaging force is generated between the gear on the input shaft side of the transmission and the gear on the output shaft side thereof. Even if the output of the engine is not decreased, therefore, the driver can easily perform the clutchless shifting. In this case, the shock in the vehicle due to the decrease in the output of the engine is not generated. This prevents the driving feeling of the vehicle from being negatively impacted, which can prevent the driver from having an uncomfortable feeling.

[0039] The results described above enable comfortable driving of the vehicle.

[0040] According to another preferred embodiment of the present invention, a vehicle includes a drive wheel, an engine that generates a torque for rotating the drive wheel, a transmission that transmits the torque generated by the engine to the drive wheel, a clutch provided between the engine and the transmission, an engine output adjuster that adjusts the output of the engine when a driver performs a shift operation of the transmission, and an inhibiting mechanism that inhibits the clutch from being disconnected by the driver when the output of the engine is adjusted by the engine output adjuster.

[0041] In the vehicle, the torque generated by the engine can be transmitted to the drive wheel through the clutch and the transmission.

[0042] Furthermore, when the driver performs the shift operation of the transmission, the output of the engine is adjusted. Thus, an engaging force of a gear on the input shaft side of the transmission with a gear on the output shaft side thereof is decreased, so that the gears to be easily moved away from each other. As a result, the driver can easily perform clutchless shifting.

[0043] When the output of the engine is adjusted by the engine output adjuster, the inhibiting mechanism inhibits the clutch from being disconnected by the driver. In this case, the clutch can be prevented from being disconnected by the driver while the output of the engine is adjusted by the engine output adjuster. This can prevent a shock unexpected for the driver from being generated in the vehicle in the shift operation. As a result, the driving feeling of the vehicle can be prevented from being decreased.

[0044] Furthermore, since the inhibiting mechanism inhibits the clutch from being disconnected, the driver can easily recognize that the output of the engine is adjusted by the engine output adjuster. Even when the driver tries to erroneously disconnect the clutch while the output of the engine is adjusted, therefore, the driver can immediately interrupt the operation. As a result, the driving feeling of the vehicle can be reliably prevented from being negatively impacted.

[0045] The results described above enable comfortable driving of the vehicle.

[0046] Other features, elements, characteristics, and advantages of the present invention will become more apparent from the following description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] FIG. **1** is a schematic side view of a motorcycle.

[0048] FIG. **2** is a diagram explaining structures of a transmission and a shift mechanism provided in the motorcycle of FIG. **1**.

[0049] FIGS. **3**A and **3**B are schematic diagrams showing a structure in which a torque is transmitted from a main shaft to a drive shaft.

[0050] FIG. **4** is a diagram showing a fixed grip, a clutch lever, and a shift switch, as viewed from the top.

[0051] FIG. **5** is a diagram showing the fixed grip, the clutch lever, and the shift switch, as viewed from the top.

[0052] FIG. **6** is a vertical sectional view taken along a line A-A of the shift switch shown in FIG. **4**.

[0053] FIG. **7** is a diagram showing the fixed grip, the clutch lever, and the shift switch, as viewed from the top.

[0054] FIG. **8** is a diagram showing the fixed grip, the clutch lever, and the shift switch, as viewed from the top.

[0055] FIG. **9** is a diagram explaining a shift switch according to a preferred embodiment of the present invention.

[0056] FIG. **10** is a diagram explaining the shift switch according to a preferred embodiment of the present invention.

[0057] FIG. **11** is a diagram explaining the shift switch according to a preferred embodiment of the present invention.

[0058] FIG. **12** is a diagram explaining the shift switch according to a preferred embodiment of the present invention.

[0059] FIG. **13** is a diagram explaining the shift switch according to a preferred embodiment of the present invention.

[0060] FIGS. **14**A to **14**C are diagrams showing a relationship between a dog of a sliding gear and a dog hole of a fixed gear.

[0061] FIG. **15** is a diagram showing a schematic structure of each element related to an engine and a control of an output of the engine.

[0062] FIG. **16** is a diagram showing an example of drive state determination data stored in a RAM of an ECU.

[0063] FIGS. **17**A to **17**C are diagrams explaining a timing of an output adjustment of the engine by a CPU when a driver performs an up-shifting operation when the engine is in a driving state.

[0064] FIGS. **18**A to **18**C are diagrams explaining a timing of the output adjustment of the engine by the CPU when the driver performs a down-shifting operation when the engine is in a driven state.

[0065] FIG. **19** is a diagram showing an example of a value detected by a shift cam rotation angle sensor when gear positions are changed between the first gear and the sixth gear.

[0066] FIG. **20** is a flowchart showing an example of a control operation of the CPU.

[0067] FIG. **21** is a flowchart showing an example of the control operation of the CPU.

[0068] FIG. **22** is a flowchart showing an example of the control operation of the CPU.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0069] An engine output adjustment system and a vehicle including the same according to preferred embodiments of the present invention will now be described with reference to the drawings. Note that a motorcycle as an example of the vehicle will be described below.

First Preferred Embodiment

[0070] General Structure of Motorcycle

[0071] FIG. **1** is a schematic side view of a motorcycle to which an engine output adjustment system according to the first preferred embodiment is preferably applied.

[0072] In the motorcycle **100** of FIG. **1**, a head pipe **102** is provided at the front end of a main body frame **101**. A front fork **103** is pivotably provided at the head pipe **102**. At the lower end of the front fork **103**, a front wheel **104** is rotatably supported. A handle **105** is provided at the upper end of the head pipe **102**.

[0073] The handle **105** is provided with a fixed grip **106***a*, a clutch lever **106***b*, an accelerator grip **106***c*, a brake lever (not shown), an accelerator opening sensor SE**1** and a notification lamp **60**. A shift switch SW is provided between the fixed grip **106***a* and the clutch lever **106***b*.

[0074] The shift switch SW outputs a signal representing an ON state (hereinafter referred to as a shift signal) when it is turned on by a driver. Details of the shift switch SW will be described later. The accelerator opening sensor SE**1** detects an operation amount of the accelerator grip **106***c* by the driver (hereinafter referred to as "an accelerator opening"). The notification lamp **60** will be described later.

[0075] An engine **107** is provided at the center of the body frame **101**. An intake pipe **79** and an exhaust pipe **118** are attached to the engine **107**. A crankcase **109** is attached to the lower portion of the engine **107**. A crank angle sensor SE**2** is provided in the crankcase **109**. The crank angle sensor SE**2** detects the rotation angle of a crank **2**, described later (see FIG. **2** and FIG. **15**), of the engine **107**.

[0076] A throttle sensor SE**3** is provided in the intake pipe **79**. The throttle sensor SE**3** detects the opening of an electronically controlled throttle valve (ETV) **82** (see FIG. **5**), described later.

[0077] A transmission case **110** coupled to the crankcase **109** is provided at the lower portion of the body frame **101**. A shift cam rotation angle sensor SE**4**, a drive shaft rotation speed sensor SE**5** as well as a transmission **5** (see FIG. **2**) and a shift mechanism **7** (see FIG. **2**), described later, are provided in the transmission case **110**.

[0078] The shift cam rotation angle sensor SE**4** detects the rotation angle of a shift cam **7***b* (see FIG. **2**), described later. The drive shaft rotation speed sensor SE**5** detects the rotation speed of a drive shaft **5***b* (see FIG. **2**), described later. Details of the transmission **5** and the shift mechanism **7** will be described later.

[0079] A transmission operating mechanism **111** is provided on the side portion of the transmission case **110**. The transmission operating mechanism **111** includes a shift pedal **11**, a first coupling arm **12**, a load sensor SE**6**, a second coupling arm **13**, a pivot arm **14** and a pivot shaft **15**. One end of the pivot shaft **15** is fixed to the pivot arm **14**, and the other end thereof is coupled to the shift mechanism **7** (see FIG. **2**), described later.

[0080] For example, when up-shifting the transmission **5**, the driver depresses the shift pedal **11** to turn it in a clockwise direction (the direction indicated by the arrow in FIG. **1**). Accordingly, the first and second coupling arms **12**, **13** move towards the back of the motorcycle **100**, and the pivot arm **14** and the pivot shaft **15** turn in the clockwise direction. As a result, the shift mechanism **7** is operated, so that the transmission **5** is shifted up. Note that the shift pedal **11** is turned in a counterclockwise direction to shift down the transmission **5**. Thus, the pivot shaft **15** is turned in the direction opposite to the direction described above (the counterclockwise direction). As a result, the shift mechanism **7** is operated, so that the transmission **5** is shifted down.

[0081] The load sensor SE**6** preferably includes a load cell such as an elastic load cell (a strain gauge type, an electrostatic capacitance type or the like) or a magnetostrictive load cell, for example, and detects a tensile load and a compressive load acting on the load sensor SE**6**. When the driver turns the shift pedal **11** in the clockwise direction (an up-shifting operation), the tensile load acts on the load sensor SE**6**. When the driver turns the shift pedal **11** in the counterclockwise direction (a down-shifting operation), the compressive load acts on the load sensor SE**6**.

[0082] A fuel tank **112** is provided above the engine **107** and a seat **113** is provided in the rear of the fuel tank **112**. An ECU (Electronic Control Unit) **50** is provided under the seat **113**.

[0083] As shown in FIG. **15**, the ECU **50** includes an I/F (interface) **501**, a CPU (central processing unit) **502**, a ROM (read only memory) **503** and a RAM (random access memory) **504**. The shift signal of the shift switch SW and values detected by the above sensors SE**1**-SE**6** are applied to the CPU **502** via the I/F **501**.

[0084] The CPU **502** controls the operation of the engine **107** based on the shift signal of the shift switch SW and the values detected by the respective sensors SE**1**-SE**6**, as described later. The ROM **503** stores a control program for the CPU **502**. The RAM **504** functions as a work area for the CPU **502** while storing a first to sixth threshold values and the like, described later.

[0085] A rear arm **114** is connected to the body frame **101** so as to extend to the rear of the engine **107**. A rear wheel **115** and a rear wheel driven sprocket **116** are rotatably held by the rear arm **114**. A chain **117** is attached to the rear wheel driven sprocket **116**.

[0086] One end of an exhaust pipe **118** is attached to an exhaust port of the engine **107**. The other end of the exhaust pipe **118** is attached to a muffler **119**.

Transmission Mechanism

[0087] FIG. **2** is a diagram explaining the structures of the transmission and the shift mechanism provided in the transmission case **110** of FIG. **1**.

[0088] As shown in FIG. **2**, the transmission **5** includes a main shaft **5***a* and the drive shaft **5***b*. A plurality of transmission gears **5***c* are mounted on the main shaft **5***a*, and a plurality of transmission gears **5***d* and a rear wheel drive sprocket **5***e* are mounted on the drive shaft **5***b*. The chain **117** of FIG. **1** is attached to the rear wheel drive sprocket **5***e*.

[0089] The torque (driving force) generated by the engine **107** of FIG. **1** is transmitted to a clutch **3** through the crank **2** of FIG. **2**. The torque is further transmitted from the clutch **3** to the main shaft **5***a* of the transmission **5**. The torque is further transmitted from the main shaft **5***a* to the drive shaft **5***b* through the transmission gears **5***c*, **5***d*. The torque is further transmitted from the drive shaft **5***b* to the rear wheel **115** (FIG. **1**) through the rear wheel drive sprocket **5***e*, the chain **117** (FIG. **1**) and the rear wheel driven sprocket **116** (FIG. **1**). Accordingly, the rear wheel **115** is rotated.

[0090] FIGS. **3**A and **3**B are schematic diagrams showing the structure in which the torque is transmitted from the main shaft **5***a* to the drive shaft **5***b*.

[0091] Note that transmission gears **5***c***1** and **5***c***2** of the plurality of transmission gears **5***c* and transmission gears **5***d***1** and **5***d***2** of the plurality of transmission gears **5***d* are shown in FIGS. **3**A and **3**B.

[0092] The transmission gear **5***c***1** is mounted on the main shaft **5***a* in a serration structure. That is, the transmission gear **5***c***1** is movable in the axial direction of the main shaft **5***a*,

while being fixed to the main shaft **5***a* in the rotational direction of the main shaft **5***a*. Therefore, the rotation of the main shaft **5***a* causes the transmission gear **5***c***1** to rotate. The transmission gear **5***c***2** is rotatably mounted on the main shaft **5***a* while being inhibited from moving in the axial direction of the main shaft **5***a*.

[0093] The transmission gear **5***d***1** is rotatably mounted on the drive shaft **5***b* while being inhibited from moving in the axial direction of the drive shaft **5***b*. When the transmission gear **5***c***1** and the transmission gear **5***d***1** are engaged with each other, the rotation of the main shaft **5***a* causes the transmission gear **5***d***1** to rotate as shown in FIG. **3**A.

[0094] The transmission gear **5***d***2** is mounted on the drive shaft **5***b* in the serration structure. That is, the transmission gear **5***d***2** is movable in the axial direction of the drive shaft **5***b* while being fixed to the drive shaft **5***b* in the rotational direction of the drive shaft **5***b*. Therefore, the rotation of the transmission gear **5***d***2** causes the drive shaft **5***b* to rotate.

[0095] As shown in FIG. **3**A, when the transmission gear **5***d***2** is spaced apart from the transmission gear **5***d***1**, the transmission gear **5***d***1** is not fixed to the drive shaft **5***b* in the rotational direction of the drive shaft **5***b*. In this case, the rotation of the main shaft **5***a* causes the transmission gear **5***d***1** to rotate, but does not cause the drive shaft **5***b* to rotate. This state where the torque (driving force) is not transmitted from the main shaft **5***a* to the drive shaft **5***b* is referred to as the state where the gears are in neutral positions.

[0096] As shown in FIG. **3**B, the transmission gear **5***d***2** moves in the axial direction to be proximate to the transmission gear **5***d***1**, so that convex-shaped dogs **5***f* provided on a side surface of the transmission gear **5***d***2** engage with concave-shaped dog holes provided on a side surface of the transmission gear **5***d***1** (not shown). In this way, the transmission gears **5***d***1** and **5***d***2** are fixed to each other. In this case, the rotation of the main shaft **5***a* causes the transmission gear **5***d***2** to rotate together with the transmission gear **5***d***1**. Accordingly, the drive shaft **5***b* is rotated.

[0097] Note that when the transmission gear **5***c***1** in the state of FIG. **3**A is moved to the proximity of the transmission gear **5***c***2** to be fixed to the transmission gear **5***c***2**, the transmission gear **5***c***2** rotates with the transmission gear **5***c***1**. In this case, the transmission gear **5***d***2** is rotated in accordance with the rotation of the transmission gear **5***c***2**. Thus, the drive shaft **5***b* is rotated. Hereinafter, transmission gears, such as the transmission gears **5***c***1**, **5***d***2**, which move in the axial direction on the main shaft **5***a* or the drive shaft **5***b* will be referred to as sliding gears. In addition, transmission gears, such as the transmission gears **5***c***2**, **5***d***1**, which are inhibited from moving in the axial direction of the main shaft **5***a* or the drive shaft **5***b* will be referred to as fixed gears.

[0098] In the transmission **5**, a transmission path of the torque (driving force) from the main shaft **5***a* to the drive shaft **5***b* can be changed by moving the sliding gears to change the combination of the sliding gears and the fixed gears, as described above. Thus, the rotational speed of the drive shaft **5***b* can be changed. Note that the sliding gears are moved by a shift arm **7***a*, described later.

[0099] As shown in FIG. **2**, the shift mechanism **7** includes the shift arm **7***a*, the shift cam **7***b* and a plurality of shift forks **7***c*. One end of the shift arm **7***a* is fixed to the pivot shaft **15** and the other end is coupled to one end of the shift cam **7***b*. A plurality of cam grooves **7***d* are formed in the shift cam **7***b*. The plurality of shift forks **7***c* are attached to the plurality of cam grooves **7***d*, respectively. The shift cam rotation angle sensor SE**4** is provided at the other end of the shift cam **7***b*.

[0100] As described above, when the driver turns the shift pedal **11**, the pivot shaft **15** is turned accordingly. With the pivot shaft **15** turned, the shift arm **7***a* is turned at one end as a central axis. This causes the shift cam **7***b* to turn. The turn of the shift cam **7***b* causes the shift forks **7***c* to move along the cam grooves **7***d*, respectively. Accordingly, the sliding gears are moved, so that the transmission path of the torque (driving force) from the main shaft **5***a* to the drive shaft **5***b* is changed. That is, a gear ratio of the transmission **5** is changed.

Shift Switch

[0101] When the driver operates the shift pedal **11** (FIG. **1**) with the shift switch SW (FIG. **1**) turned on (hereinafter referred to as a shift operation), the CPU **502** adjusts the output of the engine (see FIG. **15**). Thus, the driver can easily perform clutchless shifting.

[0102] Here, in the present preferred embodiment, the driver cannot perform a clutch operation with the shift switch SW turned on. This prevents the clutch **3** from being disconnected while the output of the engine **107** is adjusted by the CPU **502**. As a result, a great shock can be prevented from being generated in the motorcycle **100** during the shift operation. Description is now made of the structure of the shift switch SW using the drawings.

[0103] First, the positional relationship among the fixed grip **106***a*, the clutch lever **106***b*, and the shift switch SW will be described.

[0104] FIGS. **4** and **5** are diagrams showing the fixed grip **106***a*, the clutch lever **106***b*, and the shift switch SW, as viewed from the top. FIG. **4** illustrates a state in a normal operation (a state where the clutch lever **106***b* and the shift switch SW are not operated), and FIG. **5** illustrates a state where the driver is performing the clutch operation without operating the shift switch SW.

[0105] As shown in FIG. **4**, the shift switch SW is fixed to a main body **105***a* in the handle **105**. The fixed grip **106***a* is fixed to the main body **105***a*. The clutch lever **106***b* includes a bar **61** and a substantially square wide portion **62**. The wide portion **62** is pivotably attached to the main body **105***a* with a connecting pin **63**. One end of a clutch wire **65** is connected to the wide portion **62** with a fixed pin **64**. The other end of the clutch wire **65** is connected to the clutch **3** (FIG. **2**).

[0106] As shown in FIG. **5**, the driver grasps the bar **61** with his/her hand put on the fixed grip **106***a* so that the clutch lever **106***b* is turned around the connecting pin **63**. Thus, the clutch wire **65** is pulled, so that the clutch **3** is disconnected.

[0107] The structure of the shift switch SW will be then described. FIG. **6** is a vertical sectional view taken along a line A-A of the shift switch SW shown in FIG. **4**. FIGS. **7** and **8** are diagrams showing the fixed grip **106***a*, the clutch lever **106***b*, and the shift switch SW, as viewed from the top.

[0108] As shown in FIGS. **4** to **6**, a space **81** is formed within a fixed member **80**. The fixed member **80** is provided with a button **82** which is placed at one end of the space **81**. The shift switch SW outputs a shift signal when the button **82** is pressed.

[0109] A spring **83** is provided within the space **81**. One end of the spring **83** is fixed to the fixed member **80** at one end of the space **81**. One end of the fixed member **80** is buried in the main body **105***a*. A flange-shaped engagement portion **84** is provided at the other end of the fixed member **80**.

[0110] As shown in FIG. **6**, a moving member **90** includes a button pressing portion **91** and a supporting portion **92**. A flange-shaped engagement portion **93** is formed at one end of the button pressing portion **91**, and a flange-shaped engagement portion **94** is formed at the other end thereof. One end of the button pressing portion **91** is slidably fitted in the space **81**. The other end of the spring **83** is abutted against the one end of the button pressing portion **91**. Thus, the button pressing portion **91** is urged in a direction away from the button **82** by the spring **83**. The clutch lever **106***b* is arranged such that a lower end **62***a* of the wide portion **62** is lower than a lower end of the fixed member **80** and higher than a lower end of the supporting portion **92**.

[0111] As shown in FIGS. **4** and **6**, the button pressing portion **91** is forced out to a position where the engagement portion **93** is engaged with the engagement portion **84** in the fixed member **80** by the spring **83** in a normal operation. In this case, the button **82** is not pressed by the button pressing portion **91**, so that no shift signal is outputted from the shift switch SW.

[0112] As shown in FIG. **7**, when the driver presses the button pressing portion **91**, the button pressing portion **91** is forced into a position where the engagement portion **94** is abutted against the engagement portion **84** in the fixed member **80**. Thus, the button **82** (see FIG. **4**) is pressed by the button pressing portion **91**, so that a shift signal is outputted from the shift switch SW.

[0113] Here, as shown in FIG. **7**, when the button **82** is pressed by the button pressing portion **91**, the turning operation of the clutch lever **106***b* is inhibited by the supporting portion **92** in the present preferred embodiment. Specifically, with the wide portion **62** abutted against a side surface of the supporting portion **92**, the turn of the clutch lever **106***b* is inhibited. When the output of the engine **107** is adjusted by the CPU **502** (see FIG. **15**), therefore, the driver cannot disconnect the clutch **3** in the present preferred embodiment.

[0114] As shown in FIG. **8**, when the driver is performing the clutch operation, the button **82** is inhibited from being pressed by the button pressing portion **91**. Specifically, with the supporting portion **92** abutted against the wide portion **62**, the button pressing portion **91** is inhibited from moving. When the driver is performing the clutch operation, therefore, the output of the engine **107** is not adjusted by the CPU **502** in the present preferred embodiment.

[0115] The output adjustment of the engine **107** by the CPU **502** will be described later.

Effects

[0116] As described above, in the present preferred embodiment, the driver cannot disconnect the clutch **3** when the output of the engine **107** is adjusted by the CPU **502**. This can prevent a shock that is not expected by the driver from being generated in the motorcycle **100** in the shift operation. The results described above enable comfortable driving of the motorcycle **100**.

[0117] When the driver disconnects the clutch **3**, the driver cannot turn the shift switch SW on. This can prevent the driver from erroneously turning on the shift switch SW while performing the clutch operation. In this case, the output adjustment of the engine **7** by the CPU **502** can be prevented from being performed with the clutch **3** disconnected. This can prevent an unexpected shock from being generated in the motorcycle **100** when the driver connects the clutch **3**. The results enable comfortable driving of the motorcycle **100**.

[0118] Furthermore, in the present preferred embodiment, the turn of the clutch lever **106***b* is inhibited by the shift switch SW with the output of the engine **107** adjusted by the CPU **502**. Thus, the driver can easily recognize that the output adjustment of the engine **107** is performed by the CPU **502**. When the driver tries to erroneously operate the clutch lever **106***b*, therefore, the operation can be immediately interrupted.

[0119] Furthermore, with the clutch lever **106***b* operated by the driver, the press of the shift switch SW is inhibited by the clutch lever **106***b*. When the driver tries to erroneously press the shift switch SW, therefore, the operation can be immediately interrupted.

Second Preferred Embodiment

[0120] A motorcycle according to the second preferred embodiment differs from the motorcycle **100** according to the first preferred embodiment in the following points.

[0121] FIGS. **9** to **13** are diagrams for explaining a shift switch SW according to the second preferred embodiment. FIGS. **9** and **10** are diagrams showing a fixed grip **106***a*, a clutch lever **106***b*, and a shift switch SW, as viewed from the top. FIGS. **11** and **13** are vertical sectional views taken along a line B-B of the fixed grip **106***a*, the clutch lever **106***b*, and the shift switch SW shown in FIGS. **9** and **10**.

[0122] As shown in FIG. **9**, in the present preferred embodiment, a wide portion **62** of the clutch lever **106***b* is pivotably attached to a main body **105***a* through a connecting pin **63** at a corner farthest apart from a bar **61**. The rear of the wide portion **62** is accommodated within the main body **105***a*.

[0123] As shown in FIG. **10**, a driver grasps the bar **61** with his/her hand put on the fixed grip **106***a*, so that the clutch lever **106***b* is turned within a horizontal plane around the connecting pin **63** while causing the wide portion **62** to enter the main body **105***a*. Thus, a clutch wire **65** is pulled, so that the clutch **3** is disconnected.

[0124] As shown in FIGS. **11** to **13**, the shift switch SW includes a bar-shaped pressed member **200**, an idle member **300**, and a fixed member **400** in the present preferred embodiment.

[0125] As shown in FIGS. **9** to **13**, the pressed member **200** is inserted into the main body **105***a* from a rear surface of the main body **105***a* on the side opposite to the wide portion **62** of the clutch lever **106***b* toward the wide portion **62**. The pressed member **200** is arranged to be movable back and forth within the main body **105***a*. A flange **201** is provided at a rear end of the pressed member **200**, and a flange **202** is provided at a front end thereof.

[0126] As shown in FIGS. **11** to **13**, the idle member **300** includes a first pressed member **301** having a right-angled triangular shape in cross section, a second pressed member **302** having a right-angled triangular shape in cross section, and a bar-shaped pressed member **303**. A flange-shaped engagement portion **31** is formed at a lower end of the pressed member **303**.

[0127] The first pressed member **301** is arranged such that its inclined surface faces a tip portion of the pressed member **200** and its lower surface is horizontal. In order that an inclined surface of the second pressed member **302** faces the wide portion **62** of the clutch lever **106***b*, the other surface of the second pressed member **302** is fixed to the lower surface of the first pressed member **301**. Further, an upper end of the pressed member **303** is fixed to the lower surface of the first pressed member **301**.

[0128] The fixed member **400** is fixed to the main body **105***a* so as to extend in a vertical direction. A cylinder **401** is provided at an upper end of the fixed member **400**. In the cylinder **401**, a button **402** is provided at a substantially central portion of the bottom thereof. The shift switch SW outputs a shift signal when the button **402** is pressed.

[0129] In the cylinder **401**, a lower end of a spring **403** is fixed to the bottom thereof. An annular engagement portion **404** is formed at a substantially central portion of an inner peripheral surface of the cylinder **401**. A lower portion of the pressed member **303** is slidably inserted in the vertical direction into the cylinder **401**. This enables the idle member **300** to move in the vertical direction, while inhibiting the idle member **300** from moving in a horizontal direction. An upper end of the spring **403** is abutted against a lower end of the pressed member **303**. Thus, the pressed member **303** is urged in a direction away from the button **402** by the spring **403**.

[0130] As shown in FIG. **11**, the pressed member **303** is pressed up to a position where the engagement portion **31** is engaged with the engagement portion **404** in the fixed member **400** by the spring **403** in a normal operation. In this case, the button **402** is not pressed by the pressed member **303**, so that no shift signal is outputted from the shift switch SW.

[0131] When the driver presses the flange **201** at the rear end of the pressed member **200** forward, as indicated by an arrow X**1** in FIG. **12**, the inclined surface of the first pressed member **301** in the idle member **300** is pressed by the flange **202** at the front end. The idle member **300** is pressed by the flange **201** to move vertically downward because it cannot move in the horizontal direction. Thus, the lower end of the pressed member **303** is forced into the vicinity of the inner bottom of the cylinder **401** in the fixed member **400**, as indicated by an arrow Y**1**. As a result, the button **402** (see FIG. **11**) is pressed by the flange **31**, so that a shift signal is outputted from the shift switch SW.

[0132] Furthermore, when the driver performs a clutch operation, as indicated by an arrow X**2** in FIG. **13**, the inclined surface of the second pressed member **302** is pressed by the wide portion **62** of the clutch lever **106***b*. The idle member **300** is pressed by the wide portion **62** to move vertically upward because it cannot be moved in the horizontal direction. Thus, the pressed member **303** is pressed upward to the position where the engagement portion **31** is engaged with the engagement portion **404** in the fixed member **400**. In this case, the button **402** is not pressed by the pressed member **303**, so that no shift signal is outputted from the shift switch SW.

[0133] Here, in the present preferred embodiment, the turning operation of the clutch lever **106***b* is inhibited by the second pressed member **302** with the pressed member **200** pressed forward by the driver, as shown in FIG. **12**. Specifically, with the wide portion **62** abutted against the inclined surface of the second pressed member **302**, the turn of the clutch lever **106***b* is inhibited.

[0134] Therefore, in the present preferred embodiment, the clutch **3** is inhibited from being disconnected with the output of the engine **107** adjusted by the CPU **502** (see FIG. **15**). This can prevent a shock that is not expected by the driver from being generated in the motorcycle **100** in the shift operation. The results enable comfortable driving of the motorcycle **100**.

[0135] Furthermore, as shown in FIG. **13**, the pressed member **200** is inhibited from being pressed forward with the clutch **3** disconnected by the driver. Specifically, the pressed member **200** is inhibited from moving with the flange **202** of the pressed member **200** abutted against the inclined surface of the pressed member **301**.

[0136] Therefore, in the present preferred embodiment, the output of the engine **107** is inhibited from being adjusted by the CPU **502** with the clutch **3** disconnected by the driver. In this case, the output of the engine **7** can be prevented from being adjusted by the CPU **502** with the clutch **3** disconnected. This can prevent an unexpected shock from being generated in the motorcycle **100** in the clutch connection. These results enable comfortable driving of the motorcycle **100**.

[0137] Furthermore, with the pressed member **200** pressed forward by the driver (see FIG. **12**), the pressed member **303** cannot be moved upward unless the driver operates the clutch lever **106***b* with a force exceeding a force with which the pressed member **200** is pressed. When the driver erroneously operates the clutch operation while the output of the engine **107** is adjusted by the CPU **502** (see FIG. **15**), the clutch **3** (FIG. **2**) is not disconnected unless the driver operates the clutch lever **106***b* with a sufficiently large force.

[0138] In this case, the driver is prevented from erroneously disconnecting the clutch **3** while the output of the engine **107** is adjusted by the CPU **502**. This can prevent a shock that is not expected by the driver from being generated in the motorcycle **100** in the shift operation. Further, the driver can easily recognize that the output of the engine **107** is adjusted by the CPU **502**. When the driver tries to erroneously operate the clutch lever **106***b*, therefore, the operation can be immediately interrupted. These results enable comfortable driving of the motorcycle **100**.

[0139] Furthermore, with the clutch lever **106***b* operated by the driver (see FIG. **13**), the pressed member **303** cannot be moved downward unless it is pressed with a force exceeding a force with which the clutch lever **106***b* is operated. When the driver tries to erroneously press the pressed member **200** during the clutch operation, therefore, the shift switch SW is not turned on unless the pressed member **200** is pressed with a sufficiently large force.

[0140] In this case, the driver is prevented from erroneously turning the shift switch SW on during the clutch operation, which can prevent a shock that is not expected by the driver from being generated in the motorcycle **100** in the clutch connection. The results enable comfortable driving of the motorcycle **100**.

Another Preferred Embodiment

[0141] Although in the above preferred embodiments, description was made of the motorcycle **100** as an example of a vehicle to which the engine output adjustment system is applied, the engine output adjustment system may be applied to other vehicles such as a three-wheeled vehicle and a four-wheeled vehicle.

Example of Output Adjustment of Engine

[0142] The output adjustment of the engine **107** by the CPU **502** (see FIG. **15**) in the ECU **50** (FIG. **1**) will be described below.

Relationship Between Engine Output and Transmission Gears

[0143] First, the relationship between the output of the engine **107** and the transmission gear will be described.

[0144] In general, when shifting the gears of the transmission **5** (hereinafter referred to as "the gearshift"), the driver operates a clutch lever (not shown) to disconnect the clutch **3** (FIG. **2**). Thus, the transmission of the torque between the crank **2** (FIG. **2**) and the main shaft **5***a* is stopped. The driver operates the shift pedal **11** in this state (hereinafter referred to as "the shift operation"). This enables the driver to smoothly operate the gearshift. The reason will be described with reference to the drawings.

[0145] As described above, the convex-shaped dogs are formed on the sliding gears of the plurality of transmission gears **5***c*, **5***d*, and the concave-shaped dog holes, with which the dogs are engaged are formed on the fixed gears of the plurality of transmission gears **5***c*, **5***d*.

[0146] FIGS. **14**A to **14**C are diagrams showing the relationship between a dog of a sliding gear and a dog hole of a fixed gear. Note that FIGS. **14**A to **14**C schematically show sectional views of the portion in which the dog of the sliding gear and the dog hole of the fixed gear are formed. In addition, it is assumed that the portion of the sliding gear and the fixed gear shown in FIGS. **14**A and **14**C will move (rotate) in the direction indicated by the arrow.

[0147] FIG. **14**A shows a case in which the torque is applied from the crank **2** (FIG. **2**) to the main shaft **5***a* (FIG. **2**), and FIG. **14**B shows a case in which the torque is applied from the main shaft **5***a* to the crank **2**. Hereinafter, the case in which the torque is applied from the crank **2** to the main shaft **5***a* (the state of FIG. **14**A) is referred to as a driving state of the engine **107**, and the opposite case (the state of FIG. **14**B) is referred to as a driven state of the engine **107**. For example, the engine **107** is in the driving state when the motorcycle **100** is accelerated, and the engine **107** is in the driven state when the motorcycle **100** is decelerated. That is, the driven state of the engine **107** is a state in which an engine brake is applied.

[0148] As shown in FIGS. **14**A to **14**C, the dog hole **52** having a trapezoidal shape in cross section with its width increasing toward the bottom surface is formed in the fixed gear **51**. Moreover, the dog **54** having an inverted trapezoidal shape in cross section with its width increasing toward a tip portion thereof is formed on the sliding gear **53**.

[0149] In the driving state of the engine **107**, a front side surface of the dog **54** in the moving direction thereof abuts against a front side surface of the dog hole **52** in the moving direction thereof, as shown in FIG. **14**A. Accordingly, the tuning force of the sliding gear **53** is transmitted to the fixed gear **51** through the dog **54**. In this case, a large engaging force is generated in the contact surface of the dog hole **52** and the dog **54**. Thus, it is difficult to move the sliding gear **53** in a direction away from the fixed gear **51**.

[0150] Here, when the driver disconnects the clutch **3** (FIG. **2**), the transmission of the torque from the crank **2** (FIG. **2**) to the main shaft **5***a* (FIG. **2**) is stopped. In this case, the main shaft **5***a* is rotated by inertia. Accordingly, the engagement of the dog hole **52** with the dog **54** is released as shown in FIG. **14**C. This enables the sliding gear **53** to move in the direction away from the fixed gear **51**, so that the gearshift can be smoothly performed.

[0151] Furthermore, in the driven state of the engine **107**, a rear side surface of the dog **54** in the moving direction thereof abuts against a rear side surface of the dog hole **52** in the moving direction thereof, as shown in FIG. **14**B. Accordingly, the torque of the fixed gear **51** is transmitted to the sliding gear **53** through the dog **54**. As described above, since the engine brake is applied in the driven state of the engine **107**, the rotation of the fixed gear **51** is restricted by the sliding gear **53**. In this case, the large engaging force is generated in the contact surface of the dog hole **52** and the dog **54**. Thus, it is difficult to move the sliding gear **53** in the direction away from the fixed gear **51**.

[0152] Here, when the driver disconnects the clutch **3** (FIG. **2**), the transmission of the torque between the crank **2** (FIG. **2**) and the main shaft **5***a* (FIG. **2**) is stopped. In this case, the engine brake is released, so that the main shaft **5***a* is rotated by inertia. Thus, the engagement between the dog hole **52** and the dog **54** is released as shown in FIG. **14**C. This enables the sliding gear **53** to move in the direction away from the fixed gear **51**, so that the gearshift can be performed smoothly.

[0153] Although a case where the convex-shaped dog is formed in the sliding gear and the concave-shaped dog hole is formed in the fixed gear was taken as an example, a concave-shaped dog hole and a dog may be respectively formed in the sliding gear and the fixed gear.

Control of Engine Output

[0154] In the present preferred embodiment, the CPU **502** (FIG. **15**) of the ECU **50** (FIG. **1**) adjusts the output of the engine **107** based on the shift signal of the shift switch SW (FIG. **1**) and the values detected by the above mentioned sensors SE**1**-SE**6** (FIG. **1**). Thus, the fixed gear **51** and the sliding gear **53** can be brought into the state shown in FIG. **14**C without disconnecting the clutch **3** (FIG. **2**). As a result, the driver can operate the gearshift smoothly without disconnecting the clutch **3**. That is, the clutchless shifting can be performed smoothly. Details will now be described.

Relationship Between Engine and Each Element

[0155] FIG. **15** is a diagram showing a schematic structure of each element related to the engine **107** and the control of the output of the engine **107**.

[0156] As shown in FIG. **15**, the engine **107** includes a cylinder **71**, in which a piston **72** is arranged so as to be able to move up and down. In addition, a combustion chamber **73** is provided in the upper portion inside the cylinder **71**. The combustion chamber **73** communicates with the outside of the engine **107** through an intake port **74** and an exhaust port **75**.

[0157] An intake valve **76** capable of opening and closing is provided at a downstream open end **74***a* of the intake port **74**, and an exhaust valve **77** capable of opening and closing is provided at an upstream open end **75***a* of the exhaust port **75**. The intake valve **76** and the exhaust valve **77** are driven by a conventional cam mechanism. Above the combustion chamber **73**, an ignition plug **78** is provided to perform a spark ignition in the combustion chamber **73**.

[0158] The intake pipe **79** and the exhaust pipe **118** are attached to the engine **107** so as to communicate with the intake port **74** and the exhaust port **75**, respectively. An injector **108** for supplying a fuel into the cylinder **71** is provided in the intake pipe **79**. In addition, the electronically controlled throttle valve (ETV) **82** is provided in the intake pipe **79**.

[0159] Upon actuation of the engine **107**, air is taken from the intake port **74** into the combustion chamber **73** through the intake pipe **79** while the fuel is supplied into the combustion chamber **73** by the injector **108**. Accordingly, a fuel-air mixture is produced in the combustion chamber **73**, and the spark ignition is performed on the air-fuel mixture by the ignition plug **78**. A burned gas produced by the combustion of the

fuel-air mixture in the combustion chamber **73** is exhausted from the exhaust port **75** through the exhaust pipe **118**.

[0160] The output signal of the shift switch SW and the values detected by the accelerator opening sensor SE**1**, the crank angle sensor SE**2**, the throttle sensor SE**3**, the shift cam rotation angle sensor SE**4**, the drive shaft rotation speed sensor SE**5** and the load sensor SE**6** are applied to the ECU **50**.

Control Operation of CPU

Outline

[0161] In the present preferred embodiment, the CPU **502** of the ECU **50** (FIG. **15**) adjusts a throttle opening of the ETV **82** based on the detected value of the accelerator opening sensor SE**1** in a normal operation. Thus, the output of the engine **107** is adjusted to be a value depending on the accelerator opening. Note that the relationship between the accelerator opening and a throttle opening (the output of the engine) is stored in the ROM **503** or the RAM **504** of FIG. **15**.

[0162] Moreover, the CPU **502** detects the shift operation performed by the driver based on the detected value of the load sensor SE**6** when the shift switch SW is turned on. Then, when detecting the shift operation by the driver, the CPU **502** determines in which state the engine **107** is among the driving state, the driven state and a boundary state (the intermediate state between the driving state and the driven state), described later, based on the values detected by the crank angle sensor SE**2** and the throttle sensor SE**3**. Based on this determination, the CPU **502** adjusts the output of the engine **107**. In addition, the CPU **502** determines whether or not the gearshift is completed based on the value detected by the shift cam rotation angle sensor SE**4** and finishes the output adjustment of the engine **107** if the gearshift is determined to be completed.

[0163] For example, when the up-shifting operation or the down-shifting operation is performed by the driver while the engine **107** is in the driving state, the output of the engine **107** is temporarily decreased by the CPU **502**. Specifically, the output of the engine **107** is temporarily decreased by the CPU **502** so as to be less than the output of the engine **107** that is determined based on the accelerator opening at the time.

[0164] Alternatively, when the down-shifting operation is performed by the driver while the engine **107** is in the driven state, the output of the engine **107** is temporarily increased by the CPU **502**. Specifically, the output of the engine **107** is temporarily increased by the CPU **502** so as to be greater than the output of the engine **107** that is determined based on the accelerator opening at the time. Note that the output adjustment of the engine **107** is not performed by the CPU **502** while the engine **107** is in the boundary state.

[0165] Note that the CPU **502** decreases the output of the engine **107** by, for example, stopping the spark ignition of the fuel-air mixture performed by the ignition plug **78** (FIG. **15**), retarding an ignition timing, or decreasing a throttle opening of the ETV **82** (FIG. **15**). Furthermore, the CPU **502** increases the output of the engine **107** by, for example, increasing the throttle opening of the ETV **82**.

[0166] Details of the control operation of the CPU **502** will be described with reference to the drawings.

Determination Method of Driving State, Boundary State and Driven State

[0167] First, a determination method of the state of the engine **107** (the driving state, the boundary state and the driven state) is described. In the present preferred embodiment, the CPU **502** determines in which state the engine **107** is among the driving state, the boundary state and the driven state based on data that show the relationship between the rotation speed of the engine **107** (FIG. **15**) with no load and the throttle opening of the ETV **82** (FIG. **15**) (hereinafter referred to as "the driving state determination data").

[0168] FIG. **16** is a diagram showing an example of the driving state determination data stored in the RAM **504** (ROM **503**) of the ECU **50**. In FIG. **16**, the ordinate represents the rotation speed of the engine **107**, and the abscissa represents the throttle opening of the ETV **82**.

[0169] In FIG. **16**, the dotted line a shows the relationship between the rotation speed of the engine **107** and the throttle opening when the transmission gears **5***c*, **5***d* (FIG. **2**) are in the neutral positions. When the transmission gears **5***c*, **5***d* are in the neutral positions, the relationship between the rotation speed of the engine **107** and the throttle opening exhibits a hysteresis loop as shown in FIG. **16**. Note that the relationship shown by the dotted line a can be derived from, for example, an experiment, a simulation using a computer or other suitable method.

[0170] In the present preferred embodiment, a strip-shaped region in between two parallel straight lines circumscribing the dotted line a (the region between the one-dot and dash line b and the one-dot and dash line c) is defined as a boundary region A while a region below the one-dot and dash line b is defined as a driving region B and a region above the one-dot and dash line c is defined as a driven region C.

[0171] In the determination of the state (the driving state, the boundary state and the driven state) of the engine **107**, the CPU **502** calculates the rotation speed of the engine **107** based on the value detected by the crank angle sensor SE**2**. Then, the CPU **502** determines to which one of the above three regions the relationship between the engine **107** and the throttle opening belongs based on the calculated rotation speed and the detected value of the throttle sensor SE**3**. In this manner, the CPU **502** determines in which state the engine **107** is among the driving state, the boundary state and the driven state.

[0172] For example, the state where the rotation speed of the engine **107** is 6000 rpm and the throttle opening is 12 degrees belongs to the driving region B. In this case, the CPU **502** determines that the engine **107** is in the driving state.

[0173] Moreover, the state where the rotation speed of the engine **107** is 6000 rpm and the throttle opening is 2 degrees, for example, belongs to the driven region C. In this case, the CPU **502** determines that the engine **107** is in the driven state.

[0174] Furthermore, the state where the rotation speed of the engine **107** is 6000 rpm and the throttle opening is 6 degrees, for example, belongs to the boundary region A. In this case, the CPU **502** determines that the engine **107** is in the boundary state.

[0175] Note that the boundary state refers to the state of the engine **107** when the torque transmitted from the crank **2** (FIG. **2**) to the main shaft **5***a* (FIG. **2**) is equal to or less than a predetermined value, or when the torque transmitted from the main shaft **5***a* to the crank **2** is equal to or less than a predetermined value. That is, the torque is not substantially transmitted between the crank **2** and the main shaft **5***a* when the engine **107** is in the boundary state. In this case, the large pressure (engaging force) is not generated in the contact surface of the dog hole **52** (FIG. **14**) and the dog **54** (FIG. **14**). Therefore, the driver can easily move the sliding gear **53** in the direction away from the fixed gear **51** by operating the shift

pedal **11** without disconnecting the clutch **3** (FIG. **2**), even though the output of the engine **107** is not adjusted.

Timing of Output Adjustment of Engine

[0176] Next, the timing of the output adjustment of the engine **107** by the CPU **502** is described with reference to the drawings.

[0177] FIGS. **17**A to **17**C are diagrams for describing the timing of the output adjustment of the engine **107** by the CPU **502** when the driver performs the up-shifting operation when the engine **107** is in the driving state. In addition, FIGS. **18**A to **18**C are diagrams for use in describing the timing of the output adjustment of the engine **107** by the CPU **502** when the driver performs the down-shifting operation when the engine **107** is in the driven state.

[0178] Note that FIG. **17**A and FIG. **18**A show output waveforms (detected values) of the load sensor SE**6**, while FIG. **17**B and FIG. **18**B show output waveforms (detected values) of the shift cam rotation angle sensor SE**4**. In FIGS. **17**A and **17**B and FIGS. **18**A and **18**B, the ordinates represent voltage and the abscissas represent time. In addition, FIG. **17**C and FIG. **18**C show the rotation speed of the engine **107**. In FIG. **17**C and FIG. **18**C, the ordinates represent the rotation speed, and the abscissas represent time.

[0179] First, FIGS. **17**A to **17**C are described. As shown in FIG. **17**C, the rotation speed of the engine **107** is increased as time passes when the engine **107** is in the driving state. In the example of FIGS. **17**A to **17**C, the driver starts the up-shifting operation at a point t**1** within the period where the rotation speed of the engine **107** is being increased.

[0180] The detected value (voltage value) of the load sensor SE**6** is increased in accordance with the increase of the operation amount of the shift pedal **11** (FIG. **2**) by the driver, as shown in FIG. **17**A. Then, the detected value of the load sensor SE**6** becomes a maximum value a, at a point t**3** immediately before the engagement of the fixed gear **51** (FIG. **14**) with the sliding gear **53** (FIG. **14**) is released.

[0181] With the engagement of the fixed gear **51** with the sliding gear **53** being released, the driver lifts his/her foot off the shift pedal **11**. Thus, the detected value of the load sensor SE**6** drops from the maximum value a to zero, as shown in FIG. **17**A.

[0182] As shown in FIG. **17**B, the detected value (voltage value) of the shift cam rotation angle sensor SE**4** gradually drops in accordance with the increase of the operation amount of the shift pedal **11** by the driver, and rapidly drops due to the release of the engagement of the fixed gear **51** with the sliding gear **53**.

[0183] Note that deflections or play exist in each structural element of the transmission operating mechanism **111** (FIG. **2**) and the shift mechanism **7** (FIG. **2**). Therefore, the detected values of the load sensor SE**6** and the shift cam rotation angle sensor SE**4** unstably vary between the points t**1** and t**3**.

[0184] Here, in the present preferred embodiment, the output adjustment of the engine **107** is started at a point t**2** where the detected value (voltage value) of the load sensor SE**6** reaches a value b, and the output of the engine **107** is subsequently reduced. Thus, the rotation speed of the engine **107** is decreased as shown in FIG. **17**C, so that the pressure (engaging force) in the contact surface of the dog hole **52** (FIGS. **14**A to **14**C) of the fixed gear **51** (FIGS. **14**A to **14**C) and the dog **54** (FIGS. **14**A to **14**C) of the sliding gear **53** (FIGS. **14**A to **14**C) is reduced. As a result, the state of the fixed gear **51** and the sliding gear **53** is changed from the engaged state shown in FIG. **14**A to the released state described in FIG. **14**C. This enables the sliding gear **53** to easily move in the direction away from the fixed gear **51**, so that the driver can operate the gearshift without disconnecting the clutch **3** (FIG. **2**).

[0185] Note that there will be substantially no play in each structural element of the transmission operating mechanism **111** and the shift mechanism **7** when the detected value of the load sensor SE**6** reaches the value b in the example of FIG. **17**A. That is, the release operation of the dog hole **52** and the dog **54** is started when the detected value of the load sensor SE**6** reaches the value b. Accordingly, the output adjustment of the engine **107** is started when the release operation of the dog hole **52** and the dog **54** is started in the present preferred embodiment.

[0186] Moreover, the output adjustment of the engine **107** is finished at a point t**4** where the engagement of the fixed gear **51** with the sliding gear **53** is released and the detected value of the shift cam rotation angle sensor SE**4** (FIG. **17**B) becomes a value d, and the output of the engine **107** is subsequently increased again. This causes the rotation speed of the engine **107** to increase again, as shown in FIG. **17**C. As a result, the fixed gear **51** and the sliding gear **53** are engaged with each other (the engaged state of FIG. **14**A), so that the gearshift is completed.

[0187] Note that since the engagement of the fixed gear **51** with the sliding gear **53** is released at the point t**4**, the detected value of the load sensor SE**6** becomes a value a**1** that is slightly lower than the maximum value a, as shown in FIG. **17**A.

[0188] Next, FIGS. **18**A to **18**C are described. As shown in FIG. **18**C, the rotation speed of the engine **107** is decreased as time passes when the engine **107** is in the driven state. In the example of FIGS. **18**A to **18**C, the driver starts the down-shifting operation at a point t**5** within the period where the rotation speed of the engine **107** is being decreased.

[0189] As shown in FIG. **18**A, the detected value of the load sensor SE**6** is decreased in accordance with the increase of the operation amount of the shift pedal **11** (FIG. **2**) by the driver. Then, the detected value of the load sensor SE**6** becomes a minimum value −a, at a point t**7** immediately before the engagement of the fixed gear **51** (FIGS. **14**A to **14**C) with the sliding gear **53** (FIGS. **14**A to **14**C) is released.

[0190] With the engagement of the fixed gear **51** with the sliding gear **53** being released, the driver lifts his/her foot off the shift pedal **11**. Accordingly, the detected value of the load sensor SE**6** is increased from the minimum value −a to zero, as shown in FIG. **18**A.

[0191] The detected value (voltage value) of the shift cam rotation angle sensor SE**4** is gradually increased in accordance with the increase of the operation amount of the shift pedal **11** by the driver, and is rapidly increased due to the release of the engagement of the fixed gear **51** with the sliding gear **53**, as shown in FIG. **18**B.

[0192] Here, in the present preferred embodiment, the output adjustment of the engine **107** is started at a point t**6** where the detected value (voltage value) of the load sensor SE**6** reaches a value-b, and the output of the engine **107** is subsequently increased. Thus, as shown in FIG. **18**C, the rotation speed of the engine **107** is increased, and the pressure (engaging force) in the contact surface of the dog hole **52** (FIGS. **14**A to **14**C) of the fixed gear **51** (FIGS. **14**A to **14**C) and the dog **54** (FIGS. **14**A to **14**C) of the sliding gear **53** (FIGS. **14**A to **14**C) is reduced. As a result, the state of the fixed gear **51** and the sliding gear **53** is changed from the engaged state shown

in FIG. **14**B to the released state described in FIG. **14**C. This enables the sliding gear **53** to easily move in the direction away from the fixed gear **51**, whereby the driver can operate the gearshift without disconnecting the clutch **3** (FIG. **2**).

[0193] Note that there will be substantially no play in each structural element of the transmission operating mechanism **111** and the shift mechanism **7** when the detected value of the load sensor SE**6** reaches the value −b, in the example of FIG. **18**A. That is, the release operation of the dog hole **52** and the dog **54** is started when the detected value of the load sensor SE**6** reaches the value −b. Thus, the output adjustment of the engine **107** is started when the release operation of the dog hole **52** and the dog **54** is started in the present preferred embodiment.

[0194] Furthermore, the output adjustment of the engine **107** is finished at a point t**8** where the engagement of the fixed gear **51** with the sliding gear **53** is released and the detected value of the shift cam rotation sensor SE**4** (FIG. **18**B) reaches a value e, and the output of the engine **107** is subsequently decreased again. This causes the rotation speed of the engine **107** to decrease again, as shown in FIG. **18**C. As a result, the fixed gear **51** and the sliding gear **53** are again in the engaged state (the engaged state of FIG. **14**B), so that the gearshift is completed.

[0195] Note that since the engagement of the fixed gear **51** with the sliding gear **53** is released at the point t**8**, the detected value of the load sensor SE**6** becomes a value −a**1** that is slightly higher than the minimum value −a, as shown in FIG. **18**A.

[0196] As described above, the output adjustment of the engine **107** is started when an absolute value of the detected value (voltage value) of the load sensor SE**6** becomes at least the value b in the present preferred embodiment. In addition, the output adjustment of the engine **107** is finished when the detected value of the shift cam rotation angle sensor SE**4** becomes equal to or less than the value d in the up-shifting operation. In the down-shifting operation, the output adjustment of the engine **107** is finished when the detected value of the shift cam rotation angle sensor SE**4** becomes at least the value e. Furthermore, the CPU **502** determines that the gearshift is completed when the absolute value of the detected value of the load sensor SE**6** becomes equal to or less than the value c that is smaller than the value b.

Control Flow

[0197] Next, details of the control operation of the CPU **502** are described.

[0198] Note that the absolute value of the detected value of the load sensor SE**6** when the output adjustment of the engine **107** is started is referred to as a first threshold value in the following description. In addition, the detected value of the shift cam rotation angle sensor SE**4** when the output adjustment of the engine **107** is finished in the up-shifting operation is referred to as a second threshold value. Moreover, the detected value of the shift cam rotation angle sensor SE**4** when the output adjustment of the engine **107** is finished in the down-shifting operation is referred to as a third threshold value. Furthermore, the absolute value of the detected value of the load sensor SE**6** in which the gearshift is determined to be completed is referred to as a fourth threshold value. In the examples of FIGS. **17**A to **17**C and FIGS. **18**A to **18**C, the values b, d, e, and c correspond to the first, second, third, and fourth threshold values, respectively.

[0199] Note that the detected value of the shift cam rotation angle sensor SE**4** varies depending on the gear positions. FIG. **19** is a diagram showing an example of the detected value (voltage value) of the shift cam rotation angle sensor SE**4** when the gear positions are changed between the first gear and the sixth gear. Note that the ordinate represents voltage and the abscissa represents time in FIG. **19**.

[0200] As shown in FIG. **19**, the detected value of the shift cam rotation angle sensor SE**4** is high when the gears are in low speed positions, and becomes smaller as the gears move to higher speed positions. Thus, the second and third threshold values vary depending on the gear positions.

[0201] Note that the first to fourth threshold values and the fifth and sixth threshold values, described later, are stored in the RAM **504** of the ECU **50** (FIG. **15**).

[0202] FIGS. **20** to **22** are flowcharts that show an example of the control operation of the CPU **502**.

[0203] As shown in FIG. **20**, the CPU **502** first determines whether or not the shift switch SW (FIG. **1**) is turned on (step S**1**). When the shift switch SW is turned on, the CPU **502** determines whether or not the absolute value of the detected value of the load sensor SE**6** is not less than the first threshold value (corresponding to the value b of FIGS. **17**A and **18**A) (step S**2**). Note that in the step S**2**, the CPU **502** may determine whether or not the absolute value of the detected value of the load sensor SE**6** exceeds the first threshold value for a predetermined period or longer, since the detected value of the load sensor SE**6** includes noises in some cases.

[0204] When the absolute value of the detected value of the load sensor SE**6** is at least the first threshold value, the CPU **502** determines whether or not the rotation speed of the engine **107** is at least the fifth threshold value (approximately 1500 rpm, for example) and the speed of a vehicle body is at least the sixth threshold value (approximately 15 km/h, for example) (step S**3**). Note that the speed of the vehicle body of the motorcycle **100** is calculated by the CPU **502** based on the detected value of the drive shaft rotation speed sensor SE**5**. Effects of providing the process of the step S**3** will be described later.

[0205] When the rotation speed of the engine **107** is at least the fifth threshold value and the speed of the vehicle body is at least the sixth threshold value, the CPU **502** determines whether or not the up-shifting operation is performed by the driver (step S**4**). Note that the CPU **502** determines that the up-shifting operation is performed when the detected value of the load sensor SE**6** is a positive value, and determines that the down-shifting operation is performed when the detected value of the load sensor SE**6** is a negative value.

[0206] When the up-shifting operation is performed by the driver, the CPU **502** determines whether or not the engine **107** is in the driving state (step S**5**) as shown in FIG. **21**. The CPU **502** decreases the output of the engine **107** by stopping the ignition of the fuel-air mixture by an ignition plug **78** when the engine **107** is in the driving state (step S**6**). As described above, the output of the engine **107** is decreased in a process of the step S**6**, so that the sliding gear **53** can be easily moved in the direction away from the fixed gear **51**.

[0207] Next, the CPU **502** determines whether or not the detected value of the shift cam rotation angle sensor SE**4** is equal to or less than the second threshold value (corresponding to the value d of FIG. **17**B) (step S**7**). Note that the CPU **502** may determine whether or not the detected value of the shift cam rotation angle sensor SE**4** is less than the second threshold value for a predetermined period or longer in the

step S7, since the detected value of the shift cam rotation angle sensor SE4 includes noises in some cases.

[0208] The CPU **502** determines that the engagement of the fixed gear **51** (FIGS. **14**A to **14**C) with the sliding gear **53** (FIGS. **14**A to **14**C) is released, and then finishes the output adjustment of the engine **107** started in the step S**6** when the detected value of the shift cam rotation angle sensor SE**4** is equal to or less than the second threshold value (step S**8**).

[0209] Next, the CPU **502** determines whether or not the absolute value of the detected value of the load sensor SE**6** is equal to or less than the fourth threshold value (step S**9**). Note that the CPU **502** may determine whether or not the absolute value of the detected value of the load sensor SE**6** is smaller than the fourth threshold value for a predetermined period or longer in the step S**9**, since the detected value of the load sensor SE**6** includes noises in some cases.

[0210] When the absolute value of the detected value of the load sensor SE**6** is equal to or less than the fourth threshold value, the CPU **502** determines that the gearshift is completed, and performs a normal control as shown in FIG. **20** (step S**10**). In the normal control of the step S**10**, the CPU **502** adjusts the throttle opening of the ETV **82** based on the detected value of the accelerator opening sensor SE**1**. Thus, the output of the engine **107** is adjusted depending on the operation amount of the accelerator grip **106** by the driver in the normal control.

[0211] When the engine **107** is not in the driving state in the step S**5** of FIG. **21**, the CPU **502** determines whether or not the engine **107** is in the boundary state (step S**11**).

[0212] When the engine **107** is in the boundary state, the CPU **502** proceeds to the step S**9** without adjusting the output of the engine **107**. Note that the engaging force of the sliding gear **53** (FIGS. **14**A to **14**C) with the fixed gear **51** (FIGS. **14**A to **14**C) is not very large in the boundary state as described above. This enables the driver to easily move the sliding gear **53** in the direction away from the fixed gear **51** without the output adjustment of the engine **107**.

[0213] When the engine **107** is not in the boundary state, that is, when the engine **107** is in the driven state in the step S**11**, the CPU **502** lights the notification lamp **60** (FIG. **1**) without adjusting the output of the engine **107** (step S**12**).

[0214] Note that the fixed gear **51** (FIGS. **14**A to **14**C) and the sliding gear **53** (FIGS. **14**A to **14**C) are maintained in the engaged state shown in FIG. **14**A, since the output of the engine **107** is not adjusted in this case. Thus, it is difficult to release the engagement of the fixed gear **51** with the sliding gear **53**. In this manner, it becomes difficult to operate the gearshift because of the control by the CPU **502** when the engine **107** is in the driven state in the step S**11**. This prevents the transmission **5** from being shifted up during deceleration. As a result, a rapid increase in the speed of the motorcycle **100** is prevented during deceleration, so that the drivability of the motorcycle **100** is improved.

[0215] Moreover, lighting of the notification lamp **60** enables the driver to easily recognize that it is difficult to operate the gearshift because of the control by the CPU. This enables the driver to quickly stop the shift operation. The results prevent the driving feeling of the motorcycle **100** from being deteriorated.

[0216] The CPU **502** proceeds to the step S**9** after lighting the notification lamp **60** in the step S**12**.

[0217] When the detected value of the shift cam rotation angle sensor SE**4** is greater than the second threshold value in the step S**7**, the CPU **502** waits until the detected value of the shift cam rotation angle sensor SE**4** becomes equal to or less than the second threshold value. That is, the CPU **502** continues the output adjustment of the engine **107** until the engagement of the fixed gear **51** with the sliding gear **53** is released.

[0218] When the absolute value of the detected value of the load sensor SE**6** is greater than the fourth threshold value in the step S**9**, the CPU **502** waits until the absolute value of the detected value of the load sensor SE**6** becomes equal to or less than the fourth threshold value.

[0219] When the up-shifting operation is not performed by the driver in the step S**4** of FIG. **20**, that is, when the down-shifting operation is performed by the driver, the CPU **502** determines whether or not the engine **107** is in the driving state as shown in FIG. **22** (step S**13**). When the engine **107** is in the driving state, the CPU **502** decreases the output of the engine **107** by stopping the ignition of the fuel-air mixture by the ignition plug **78** (step S**14**). The output of the engine **107** is decreased in the process of this step S**14**, so that the sliding gear **53** can be easily moved in the direction away from the fixed gear **51** as described above.

[0220] Next, the CPU **502** determines whether or not the detected value of the shift cam rotation angle sensor SE**4** is at least the third threshold value (corresponding to the value e of FIG. **18**B) (step S**15**). Note that the CPU **502** may determine whether or not the detected value of the shift cam rotation angle sensor SE**4** exceeds the third threshold value for a predetermined period or longer in the step S**15**, since the detected value of the shift cam rotation angle sensor E**4** includes noises in some cases.

[0221] When the detected value of the shift cam rotation angle sensor SE**4** is at least the third threshold value, the CPU **502** determines that the engagement of the fixed gear **51** (FIGS. **14**A to **14**C) with the sliding gear **53** (FIGS. **14**A to **14**C) is released, and then finishes the output adjustment of the engine **107** started in the step S**14** or a step S**18**, described later (step S**16**). Then, the CPU **502** proceeds to the step S**9** of FIG. **21**.

[0222] When the engine **107** is not in the driving state in the step S**13** of FIG. **22**, the CPU **502** determines whether or not the engine **107** is in the boundary state (step S**17**).

[0223] When the engine **107** is in the boundary state, the CPU **502** proceeds to the step S**9** of FIG. **21** without adjusting the output of the engine **107**. Note that the driver can easily move the sliding gear **53** (FIGS. **14**A to **14**C) in the direction away from the fixed gear **51** (FIGS. **14**A to **14**C) without the output adjustment of the engine **107** in the boundary state, as described above.

[0224] When the engine **107** is not in the boundary state in the step S**17** of FIG. **22**, that is, when the engine **107** is in the driven state, the CPU **502** increases the throttle opening of the ETV **82** and increases the output of the engine **107** (the step S**18**). The output of the engine **107** is increased in the process of this step S**18**, so that the sliding gear **53** can be easily moved in the direction away from the fixed gear **51** as described above. Then, the CPU **502** proceeds to the step S**15**.

[0225] When the detected value of the shift cam rotation angle sensor SE**4** is less than the third threshold value in the step S**15**, the CPU **502** waits until the detected value of the shift cam rotation angle sensor SE**4** becomes at least the third threshold value. That is, the CPU **502** continues the output adjustment of the engine **107** until the engagement of the fixed gear **51** with the sliding gear **53** is released.

[0226] When the shift switch SW (FIG. **1**) is turned off in the step S**1** of FIG. **20**, the CPU **502** determines that the driver does not permit the output adjustment of the engine **107**, and then proceeds to the step S**10** to perform normal control.

[0227] When the absolute value of the detected value of the load sensor SE**6** is less than the first threshold value in the step S**2**, the CPU **502** determines that the shift operation is not started by the driver, and then proceeds to the step S**10** to perform the normal control.

[0228] In addition, when the rotation speed of the engine **107** is less than the fifth threshold value or the speed of the vehicle body is less than the sixth threshold value in the step S**3**, the CPU **502** proceeds to the step S**12** of FIG. **21** and lights the notification lamp **60** (FIG. **1**) without controlling the output of the engine **107**.

[0229] Note that since the output of the engine **107** is not adjusted in this case, a rapid change in the output of the engine **107** is prevented during low speed driving. This prevents the rear wheel **115** (FIG. **1**) from slipping and prevents the driving feeling of the motorcycle **100** from being negatively impacted.

[0230] Furthermore, in this case, the fixed gear **51** (FIGS. **14**A to **14**C) and the sliding gear **53** (FIGS. **14**A to **14**C) are maintained in the engaged state shown in FIG. **14**A. Thus, the gearshift is prevented since it is difficult to release the engagement of the fixed gear **51** with the sliding gear **53**. Accordingly, a rapid change in the speed of the motorcycle **100** is prevented during low speed driving, and the drivability of the motorcycle **100** is improved.

[0231] Moreover, lighting of the notification lamp **60** enables the driver to easily recognize that it is difficult to operate the gearshift because of the control by the CPU **502**. This enables the driver to stop the shift operation quickly. The results prevent the driving feeling of the motorcycle **100** from being deteriorated.

Effects

[0232] As described above, the output of the engine **107** is decreased by the CPU **502** when the engine **107** is in the driving state when the driver performs the up-shifting operation or the down-shifting operation in the present preferred embodiment. In addition, the output of the engine **107** is increased by the CPU **502** when the engine **107** is in the driven state when the driver performs the down-shifting operation. Accordingly, the pressure (engaging force) generated in the contact surface of the fixed gear **51** and the sliding gear **53** is reduced, so that the driver can perform the clutchless shifting smoothly.

[0233] The control by the CPU **502** makes it difficult to operate the gearshift when the engine **107** is in the driven state when the up-shifting operation is performed by the driver. This can prevent the transmission **5** from being shifted up during the deceleration of the motorcycle **100**. The results prevent the rapid increase in the speed of the motorcycle **100** during the deceleration, and prevent the driving feeling of the motorcycle **100** from being negatively impacted.

[0234] When it is difficult to operate the gearshift, the notification lamp **60** is lit by the CPU **502**. In this case, the driver can easily recognize that the CPU **502** makes it difficult to operate the gearshift. Thus, the driver can quickly stop the shift operation. As a result, the drivability of the motorcycle **100** is further improved. In addition, the driver can easily determine whether or not a failure is occurring in the motorcycle **100** by confirming the state of the notification lamp **60**, even if the clutchless shifting cannot be performed.

[0235] The foregoing results enable the driver to enjoy comfortably driving the motorcycle **100**.

[0236] When the motorcycle **100** is driven at a low speed, the control by the CPU **502** makes it difficult to operate the gearshift. Accordingly, the rapid change in the speed of the motorcycle **100** is prevented during low speed driving. This prevents the rear wheel **115** from slipping, and prevents the driving feeling of the motorcycle **100** from being deteriorated. Also in this case, the driver can quickly interrupt the shift operation and can easily determine whether or not a failure is occurring in the motorcycle **100** by confirming the state of the notification lamp **60**.

[0237] The CPU **502** performs the normal control when the engine **107** is in the boundary state when the driver performs the up-shifting operation or the down-shifting operation. That is, the output of the engine **107** is not adjusted when the torque having at least a predetermined value is not transmitted between the engine **107** (the crank **2**) and the transmission **5** (the main shaft **5***a*).

[0238] Here, as described above, the large pressure (engaging force) is not generated in the contact surface of the fixed gear **51** and the sliding gear **53** when the torque transmitted between the engine **107** and the transmission **5** is small. Thus, the driver can perform the clutchless shifting easily even though the output of the engine **107** is not adjusted. In this case, a shock generated by the adjustment of the output of the engine **107** can be prevented, which prevents the driving feeling of the motor cycle **100** from being negatively impacted. This enables the driver to enjoy comfortably driving the motorcycle **100**.

[0239] Providing the boundary state can prevent the output control of the engine **107** that should be performed in the driven state from being performed in the driving state, and prevent the output control of the engine **107** that should be performed in the driving state from being performed in the driven state. This can avoid the output of the engine **107** from being adjusted improperly even if the determination as to whether the engine **107** is in the driving state or the driven sate cannot be properly made because the engine **107** is in the vicinity of the boundary between the driving state and the driven state. This enables the clutchless shifting to be smoothly performed, and prevents the driving feeling of the motorcycle **100** from being deteriorated.

[0240] Note that an appropriate period of time for the output adjustment sometimes cannot be ensured when the adjustment of the output of the engine **107** is finished based on the rotation speed of the engine **107**, the elapsed time after the shift operation or the like. Thus, the clutchless shifting cannot be performed smoothly in some cases.

[0241] In contrast, the adjustment of the output of the engine **107** is determined to be finished based on the detected value of the shift cam rotation angle sensor SE**4** in the present preferred embodiment. Accordingly, the adjustment of the output of the engine **107** can be finished at the most appropriate timing regardless of the operation amount and the operation speed of the shift pedal **11** by the driver. This enables the clutchless shifting to be performed more quickly, and easily makes the output of the engine **107** stable.

[0242] In addition, the ignition of the fuel-air mixture by the ignition plug **78** is stopped, so that the output of the engine **107** is decreased in the present preferred embodiment. In this

case, the output of the engine **107** can be rapidly decreased. This enables the clutchless shifting to be performed quickly.

[0243] Furthermore, the state (the driving state, the boundary state and the driven state) of the engine **107** is determined based on the driving state determination data stored in the RAM **504** (ROM **503**) in the present preferred embodiment. In this case, a sensor for detecting the transmission state of the torque is not required, so that a production cost of the motorcycle **100** can be reduced.

Another Example of Output Adjustment of Engine

[0244] While the output of the engine **107** is decreased by stopping the ignition of the fuel-air mixture by the ignition plug **78** in the step S**6** of FIG. **21** and the step S**14** of FIG. **22** in the above described preferred embodiment, the output of the engine **107** may be decreased by retarding the ignition timing. In addition, the output of the engine **107** may be decreased by controlling the ETV **82**.

[0245] Moreover, while the adjustment of the output of the engine **107** is finished immediately after the engagement of the fixed gear **51** with the sliding gear **53** is released (at the point t**4** in FIG. **17** and the point t**8** in FIG. **18**) in the above described preferred embodiment, the adjustment of the output of the engine **107** may be finished at other timings. For example, the adjustment of the output of the engine **107** may be finished in the vicinity of a point of time where the sliding gear **53** moves to engage with another fixed gear **51**. In this case, the second threshold value (the value d of FIG. **17**B) is decreased, and the third threshold value (the value e of FIG. **18**B) is increased.

[0246] Furthermore, while the state (the driving state, the boundary state and the driven sate) of the engine **107** is determined based on the driving state determination data in the above described preferred embodiment, the state (the driving state, the boundary state and the driven sate) of the engine **107** may be determined by other methods.

[0247] For example, a three-dimensional map that shows the relationships among the rotation speed of the engine **107**, the throttle opening of the ETV **82** and the torque (driving force) generated by the engine **107** may be stored in the RAM **504** (ROM **503**) in the ECU **50**. In this case, the torque generated by the engine **107** can be derived from the three-dimensional map based on the rotation speed of the engine **107** and the throttle opening of the ETV **82**. Then, it may be determined that the engine **107** is in the driving state when the derived torque is a positive value of at least a predetermined value, that it is in the boundary state when the absolute value of the derived torque is less than the predetermined value, and that it is in the driven state when the absolute value of the derived torque is a negative value of at least the predetermined value.

[0248] In the following two paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various preferred embodiments of the present invention are explained.

[0249] In the preferred embodiments described above, the CPU **502** is an example of an engine output adjuster, the shift switch SW and the clutch lever **106***b* are examples of an inhibiting mechanism, the clutch lever **106***b* is an example of a clutch operating member, the shift switch SW is an example of a switch mechanism, the moving member **90** is an example of a first moving portion, the wide portion **62** is an example of a second moving portion or a fourth moving portion, the pressed member **200** is an example of a third moving portion, and the rear wheel **115** is an example of a drive wheel.

[0250] As the elements recited in the claims, various other elements having the structure or function recited in the claims may be used and included.

[0251] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. An engine output adjustment system that adjusts an output of an engine in a vehicle that transmits a torque generated by the engine to a drive wheel through a clutch and a transmission, the engine output adjustment system comprising:

an engine output adjuster arranged to adjust the output of the engine when a driver performs a shift operation of the transmission; and

an inhibiting mechanism arranged to inhibit the clutch from being disconnected by the driver when the output of the engine is being adjusted by the engine output adjuster.

2. The engine output adjustment system according to claim **1**, wherein the inhibiting mechanism inhibits the output of the engine from being adjusted by the engine output adjuster when the driver disconnects the clutch.

3. The engine output adjustment system according to claim **1**, wherein the inhibiting mechanism either enables the engine output adjuster to adjust the output of the engine or enables the driver to disconnect the clutch.

4. The engine output adjustment system according to claim **1**, further comprising a switch mechanism operated by the driver, wherein the engine output adjuster adjusts the output of the engine when the switch mechanism is operated and the shift operation of the transmission is performed.

5. The engine output adjustment system according to claim **4**, further comprising a clutch operating member operated by the driver so as to operate the clutch, wherein the inhibiting mechanism inhibits the clutch operating member from being operated by the driver when the driver operates the switch mechanism.

6. The engine output adjustment system according to claim **5**, wherein the inhibiting mechanism inhibits the switch mechanism from being operated by the driver when the driver operates the clutch operating member.

7. The engine output adjustment system according to claim **5**, wherein the inhibiting mechanism includes the switch mechanism and the clutch operating member, the switch mechanism includes a first moving portion that moves in synchronization with the operation by the driver, the clutch operating member includes a second moving portion that moves in synchronization with the operation by the driver, the first moving portion moves to a position where the second moving portion is inhibited from moving when the driver operates the switch mechanism, and the second moving portion moves to a position where the first moving portion is inhibited from moving when the driver operates the clutch operating member.

8. The engine output adjustment system according to claim **5**, wherein the inhibiting mechanism includes the switch mechanism and the clutch operating member, the switch mechanism includes a third moving portion that moves in a

first direction in synchronization with the operation by the driver, the clutch operating member includes a fourth moving portion that moves in a second direction in synchronization with the operation by the driver, the third moving portion urges the fourth moving portion in a direction opposite to the second direction when the driver operates the switch mechanism, and the fourth moving portion urges the third moving portion in a direction opposite to the first direction when the driver operates the clutch operating member.

9. The engine output adjustment system according to claim **1**, wherein when the driver performs the shift operation of the transmission, the engine output adjuster decreases the output of the engine when the torque is at least a first value in a driving state where the torque is transmitted from the engine to the transmission and does not decrease the output when the torque is less than the first value in the driving state.

10. A vehicle comprising:

a drive wheel;

an engine arranged to generate a torque for rotating the drive wheel;

a transmission arranged to transmit the torque generated by the engine to the drive wheel;

a clutch provided between the engine and the transmission;

an engine output adjuster arranged to adjust the output of the engine when a driver performs a shift operation of the transmission; and

an inhibiting mechanism arranged to inhibit the clutch from being disconnected by the driver when the output of the engine is adjusted by the engine output adjuster.

11. The vehicle according to claim **10**, wherein the inhibiting mechanism inhibits the output of the engine from being adjusted by the engine output adjuster when the driver disconnects the clutch.

12. The vehicle according to claim **10**, wherein the inhibiting mechanism either enables the engine output adjuster to adjust the output of the engine or enables the driver to disconnect the clutch.

13. The vehicle according to claim **10**, further comprising a switch mechanism operated by the driver, wherein the engine output adjuster adjusts the output of the engine when the switch mechanism is operated and the shift operation of the transmission is performed.

14. The vehicle according to claim **13**, further comprising a clutch operating member operated by the driver so as to operate the clutch, wherein the inhibiting mechanism inhibits the clutch operating member from being operated by the driver when the driver operates the switch mechanism.

15. The vehicle according to claim **14**, wherein the inhibiting mechanism inhibits the switch mechanism from being operated by the driver when the driver operates the clutch operating member.

16. The vehicle according to claim **14**, wherein the inhibiting mechanism includes the switch mechanism and the clutch operating member, the switch mechanism includes a first moving portion that moves in synchronization with the operation by the driver, the clutch operating member includes a second moving portion that moves in synchronization with the operation by the driver, the first moving portion moves to a position where the second moving portion is inhibited from moving when the driver operates the switch mechanism, and the second moving portion moves to a position where the first moving portion is inhibited from moving when the driver operates the clutch operating member.

17. The vehicle according to claim **14**, wherein the inhibiting mechanism includes the switch mechanism and the clutch operating member, the switch mechanism includes a third moving portion that moves in a first direction in synchronization with the operation by the driver, the clutch operating member includes a fourth moving portion that moves in a second direction in synchronization with the operation by the driver, the third moving portion urges the fourth moving portion in a direction opposite to the second direction when the driver operates the switch mechanism, and the fourth moving portion urges the third moving portion in a direction opposite to the first direction when the driver operates the clutch operating member.

18. The vehicle according to claim **10**, wherein when the driver performs the shift operation of the transmission, the engine output adjuster decreases the output of the engine when the torque is at least a first value in a driving state where the torque is transmitted from the engine to the transmission and does not decrease the output when the torque is less than the first value in the driving state.

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